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FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A.5.2.1

South Africa

EXPLORATION AND EXPLORATORY TECHNIQUES APPLICABLE IN SOUTH-CENTRAL AFRICA

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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Item A. Natural Resources.
Serial No. 1434.
Sub Item A.5.2.1.

REPUBLIC OF SOUTH AFRICA.

EXPLORATION AND EXPLORATORY TECHNIQUES APPLICABLE IN SOUTH-CENTRAL AFRICA.

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1. Introduction:-

South-Central Africa is hereby understood to include that portion of the sub-Continent of Southern Africa extending as far north as East Africa, the former Belgian Congo and Angola. It is, for practical purposes, Africa south of the Equator. This article sets out the writer's views gained as a result of exploration in these territories, with which he has been associated, or has directed, during a period of over thirty years. Exploration for petroleum is excluded as it is highly specialized and can only be carried out, at great expense, by the major oil companies who alone have the necessary facilities.

2. Economic Outlook:-

The scope and length of this article does not permit any details with regard to the regional geology but it can be said that South-Central Africa is one of the highly mineralized areas of the world and one which must continue to play an important part in the search for new mineral deposits to meet the world's future needs.

3. Necessity for Organised and Scientific Exploration:-

South-Central Africa, even in the lesser known areas, is by no means virgin country in the matter of mineral exploration. It has in fact been explored to a greater degree than many supposedly better known territories where difficulties of access, transportation, and a short field-season obtain. This means that the stage has been reached where important mineral fields, at least of the commoner minerals, are unlikely to be discovered by a mere inspection on the ground. Major mineral discoveries here, as in many parts of the world, will be increasingly the result of carefully planned and scientific methods of exploration. (1)

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(1) The only really important mineral discoveries in these territories in recent years have been in the realm of precious stones - diamonds and emeralds.

4. Scope for Individual Prospecting and Small Scale Mining:-

While this applies to major discoveries in general there is still ample scope for the prospector and especially for the small mine worker. There are many mineral fields in Southern Africa where small deposits of economic minerals prevail and where the occurrences of deposits of sufficient size for exploitation on a large scale are the exception rather than the rule. In general, deposits which require no processing and where the ore is sold as such, or where treatment is simple, lend themselves to working on a small scale and such deposits would include certain gold, chrome, asbestos and tin deposits to mention but a few. Certain other deposits such as mica, beryl, corundum, tungsten, etc. seldom lend themselves to exploitation other than on a modest scale.

5. Major Exploration Programmes:-

As we have seen in paragraph 3 the future of exploration in this territory must rely mainly on well planned and scientific methods of exploration and the essential condition is that exploration be carried out or supervised by experienced geologists. Though important surface indications of the presence of the better known minerals have already been found there are good opportunities for further major discoveries. In many regions the evidence of mineral deposits is largely obliterated by intense surface leaching under sub-tropical or tropical conditions of weathering, and over vast areas the underlying formations are masked by a thin cover of wind-blown sand. Close and concentrated work on small areas of favourable ground is more likely to yield results than vast expenditure on large areas without adequate geological direction or supervision. If large exploratory programmes are undertaken the work should be distributed into small groups each working under close supervision.

6. Geological Maps:-

All important exploratory programmes should be based on a geological map of the area to be explored. If the geological information is inadequate a geological map, on a reconnaissance scale, should be made showing in a general way the distribution of the various formations, particularly those which are suspected to contain mineral deposits. By this means work can be devoted to the more promising areas and those with a poor economic outlook discarded.

7. Aids to Exploration:-

During the last few decades certain aids have been available to assist exploration; these are geophysical and geochemical methods of prospecting and aerial photography. These aids have, in many cases, been of great assistance and some of them will undoubtedly be applicable to any major exploratory enterprise. It is the opinion of the writer, however, that too much reliance is often placed upon them at the expense of proper geological groundwork, which is their essential complement. In view of their importance they are discussed in some detail in the succeeding paragraphs inasmuch as their application to conditions pertaining to South-Central Africa is concerned.

8. Geophysical Methods of Prospecting:-

(a) Some misconceptions attach to the role of geophysical methods in exploration. The writer does not claim to have specialised knowledge of the technical details of the various methods but has been a party to the application of most of them; the following remarks are made in the light of his experience under conditions obtaining in these territories. In general geophysical methods suffer from the fact that they are too often regarded as a "magic wand" capable of finding mineral deposits by themselves, whereas in most cases they are merely an aid to the geologist and sometimes, if used without adequate geological control, can be both wasteful and misleading. The fault does not reside in the methods themselves, as physical constants independent of personal factors are measured, but in the interpretation, if based on insufficient knowledge of the geological background or physical conditions pertaining to the terrain in which they are applied. Personal preferences or prejudices also play an important part. Only too often a method, which has given an outstanding result in some particular instance where conditions were exceptionally favourable, is utilized under different conditions where it can be of little if any use. Invariably a geophysical method is first tried out on a deposit, the position of which is known, in order to find out whether it will indicate it and if so extravagant claims are made for it. This, however, is not an infallible guide to its usefulness but only the first hurdle to be overcome. A method which may disclose, by a physical anomaly, the existence of an ore deposit whose presence was previously known may in another, or even in the same terrain, disclose a multiplicity of similar anomalies from which it would be impossible to identify this orebody if its position had not been known. In geophysical prospecting it is the multiplicity of anomalies rather than the lack of them which causes trouble. The foregoing has not been written with the intention of discouraging the application of geophysical methods but of pointing out, in the true interest of these methods, certain limitation to which they may be subject.

(b) Geophysical methods of prospecting include various electrical methods, which either measure naturally occurring fields in the earth's crust or induce currents in the earth artificially. In the writer's experience these methods are those most subject to uncertainties and errors in interpretation and they are more useful in the latter stages of prospecting for the better delimitation of deposits already located. Seismic methods are all important in exploration for oil but are seldom of use for other minerals. Gravity methods have, with the perfection of the modern gravimeter, become more generally useful, but are still of limited application and are more for detailed work. The geophysical methods of prospecting most suitable for general use in exploration for reasons of their adaptability for regional work, their relative low cost and their freedom from most of the uncertainties pertaining to other methods are undoubtedly aerial scintillometer surveys, for radioactive minerals, and aerial magnetometer surveys for magnetic ores, or associated deposits, and some details regarding the application of these methods are therefore of interest.

(i) Aerial Scintillometer Surveys:- Scintillometer or geiger detection of radioactive minerals approaches the ideal geophysical method of prospecting. These are detected directly without any possibility of error or ambiguity. Aerial application by scintillometer is easy and provided flights are carried out low enough any reactions that can be picked up on the ground by geiger counters or scintillometers can likewise be detected in the air. The aircraft to be used must be small and therefore inexpensive and as the installation is easy can usually be hired for the purpose. It is essential to carry out the survey at about 300 feet above the ground and therefore such surveys are limited, both by consideration of safety and for optimum results, to flat country. Very slow speeds are not required provided the speed does not exceed 100 miles per hour. Small one-engined craft are ideal. A serious limitation, especially in this territory, is that radiation is confined to surface exposures or at most a few feet below the surface. In many areas surface leaching is pronounced and this may result in an important radioactive deposit giving but a feeble surface reaction. The strength of the radiation is therefore not necessarily a measure of the value of a deposit and even small anomalies have to be considered which results in a multiplicity of radioactive anomalies which may have to be taken into account. Aerial scintillometer surveys should be carried out on traverses preferably plotted in advance on aerial photographs. A geologist should always be in the aircraft to watch the recording drum as many of the anomalies can be immediately correlated with stream beds, isolated outcrops of granite, etc. and can be discarded as being of no importance.

Although radioactive minerals are being over-produced at the present time scintillometer surveys can be used to prospect for carbonatite occurrences which, though only feebly radioactive, will give strong anomalies in aerial scintillometer work on account of their large mass effect. In East Africa the author directed exploration which quickly confirmed by these means presumed occurrences of carbonatites and likewise disproved the existence of others. In addition several new occurrences were found. An important phosphate body, which contained low uranium values, was also discovered fortuitously by this means.

(ii) Magnetometer Surveys:- This type of survey has the advantage of being a direct method, as far as iron ores are concerned, and an outstanding achievement was the discovery by this means of the large iron ore occurrences in Labrador. The method has also the advantage that it can reveal magnetite bearing deposits at considerable depth and even beneath a cover of younger rocks. In Africa important extensions of the Witwatersrand were discovered, concealed under a thick cover of younger rocks, by defining the position of magnetic shale beds in the footwall of the gold-bearing horizons from which the position of the latter could be predicted. While instrumentation for aerial work is rather costly the rapidity with which aerial magnetometer surveys can be carried out renders the method fairly economical if the area to be explored is a large one. Usually twin-engined aircraft

of moderate size are used and flights carried out about 1,000 feet above the ground and coverage is very rapid. In addition to deposits of iron-ore, the method can be used for the detection of deposits rich in magnetite such as certain carbonatite occurrences, and manganese deposits associated with iron ore have been discovered in the northern Cape by ground methods. It is also useful for tracing magnetic formations in geological mapping which can give important information as to geological structures.

9. Geochemical Methods of Prospecting:-

(a) These methods have been perfected in recent years and have been increasingly employed in Southern Africa. They have the advantage of indicating the presence of various elements without any possible ambiguity and climatic conditions in Southern Africa in general favour their application. Samples are usually taken to conform to a grid pattern and within a foot or less from the surface. The method is rapid and the fieldwork can be reduced to a routine and carried out by unskilled labour. Analysis of the samples can be carried out chemically or spectrographically and when done on a sufficiently large scale costs are moderate.

(b) In the writer's experience, however, the usefulness of this method depends greatly on the conditions obtaining in the terrain in which it is applied. In Southern Rhodesia it has proved very successful in locating deposits of nickel in serpentine and in gabbroidal rocks. Here the surface cover of soil was small and undecomposed rock was to be found at shallow depth and exploration, based on geochemically determined nickel values, pin-pointed nickel deposits fairly accurately. In areas of high rainfall, however, where the surface soil is deep and highly leached the method is not very satisfactory. The dispersion of the elements, especially the more soluble ones, is too great and high geochemical values often have no connection with the underlying rocks, as the elements determined have been transported by surface water over a considerable distance. Under such conditions results serve to indicate possibilities in a regional sense rather than to pin-point individual deposits. In such terrain, however, the writer has used geochemical techniques to good effect in locating the copper-bearing horizon in the Lower Roan Series, to the West of the Northern Rhodesian Copper Belt, and where leaching was so pronounced that no recognisable copper anomaly could be detected at surface. Grab samples were taken at each five feet of depth in prospect pits dug at right angles to the strike at close enough intervals to expose the entire stratigraphic succession. At a depth of about 15 feet in such pits there was sufficient residual copper to disclose the position of the potential "ore shale" when the latter was mineralized. In this case, however, the method was employed rather as a quick means of assay than in its accepted use.

10. Aerial Photography:-

(a) The value of aerial photography has long been recognised. In the realm of exploration it can be put to a variety of uses not so much for the discovery of ore deposits themselves as for ancillary

services connected with exploration; it can prove to be of great assistance in geological mapping; it can be used for compiling topographical maps when existing maps are inadequate; it can serve as a basis to lay out aerial scintillometer grids for which it is almost an indispensable preliminary. For any important exploratory programme, aerial photographic survey is almost certain to be useful in some way or another and on account of its relatively low cost should be made if not available. Fortunately this will rarely be necessary as aerial photography coverage already exists for most territories, having been carried out by various government departments for military or cartographical purposes.

(b) Notwithstanding the great assistance that aerial photography provides in geological mapping it is well to be forewarned against placing too great a reliance on "photogeology" as a sure means of drawing up reliable geological maps. It is legitimate in the case of exploratory enterprises to rely to a considerable extent on aerial photographic work to delineate the more promising geological formations or structures for detailed investigation. In such cases even though ground control has been inadequate and errors may have been made this procedure is justified by the saving of time and expense. It is inadmissible, however, to rely on photo-geology for geological maps intended for public use, such as are compiled by State Geological Surveys. In such cases the results or interpretations based on photo-geology must be rigorously verified on the ground. Even so, photo-geology can be most useful in expediting geological mapping and often provides a quick insight on structures which are not readily discernable on the ground.

11. <u>State Aid</u>:-

(a) The mineral industry is a national asset of great importance and one which can give relatively quick returns, and encouragement of the industry is a wise policy, especially in the case of the lesser developed territories. State aid can be considered under the following headings:-

(i) State Geological Surveys.

(ii) A legislative policy calculated to encourage exploration and large scale mining.

(iii) Subsidies for small mine workers.

(i) A well financed Geological Survey, under whose direction geological maps of the territory will be compiled with particular reference to areas of greater economic promise, is perhaps the most important contribution which can be made by the State for the benefit of the mining industry. Geological Maps are of assistance to all; indispensable in major exploration enterprises they are also of value to the individual prospector. In these days even the humblest prospector, in the writer's experience, does make use

of geological maps, to guide him as to the distribution of certain rock types likely to contain mineral deposits, granite contacts, etc.

The writer is able to testify from personal knowledge to the excellence of the various Geological Surveys in the territories under review. While advocating an enlargement of these activities he would above all stress that the high quality of the present work be maintained and in this respect quality rather than quantity is to be desired. Detailed geological maps of large territories must be gradually built up over a long period but geological maps, even reconnaissance maps, must at all times be accurate in that they should only portray what has actually been observed on the ground without questionable interpretations, or added details, adduced as a result of the study of aerial photographs in an office.

(ii) The formulation of legislation calculated to encourage large scale exploration and mining is a complex subject rather beyond the scope of this article. It must be borne in mind that exploration and mining are very hazardous undertakings where vast sums of money may be spent without any reward so that if private enterprise is to participate in such ventures conditions will have to be made sufficiently attractive. The matter goes beyond that of mere exploration and encompasses the entire field of mining legislation.

In the matter of exploration itself it is now customary to grant large tracts of ground to important mining companies in the form of reserved areas or special grants, etc. for a limited period subject to a stipulated or negotiated yearly expenditure. This is a satisfactory arrangement as it protects the mining company by allowing time to organize exploration on a proper basis and it ensures the State that serious and well organized exploration will be carried out. With regard to possible subsequent mining operations the large mining companies will obviously insist on security of tenure as a first requisite and will expect enlightened legislation in respect of royalties, re-imbursement of prospecting expenses by remission of taxation over an initial period, etc.

(iii) In the case of the small mine worker it will be wise, in deserving cases, to assist him financially. Various means have been devised to do this, notably by loans from Mining Departments conditional upon control or supervision of his activities. In some cases these loans have been guaranteed by the grantee's personal property which the writer believes to be a misguided procedure. It is often difficult to judge if a mining venture will prove successful and this will cause embarrassment to supervising mining officials who will hesitate to encourage further development, so as not to lead the grantee into too much expenditure, and in this way a successful outcome may be prevented. In fairness to all concerned the writer considers that all loans granted for development of deserving properties, under supervision of the mining authorities, should be recoverable only if the venture proves successful and that the State should therefore

participate in the risk. The writer would suggest that perhaps the best way to assist the small worker is to hire out simple mining equipment to him. A large proportion of the cost of developing a property is the cost of equipment and if a venture proves unsuccessful the owner is faced with a large capital loss. If the State through its Department of Mines carries a stock of simple mining equipment such as small hoists, compressors, diesel power units, etc. which they can hire out, at a modest rental to cover depreciation and maintenance costs, the small mine worker can devote most of his resources to developing his property. Such a scheme is in operation in Southern Rhodesia and is proving very popular with small mine owners.

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Agenda Item: A.3.1.3

Israel

THE ROLE OF WATER LEGISLATION IN A DEVELOPING COUNTRY

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THE ROLE OF WATER LEGISLATION IN A DEVELOPING COUNTRY.

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A. INTRODUCTION.

This paper discusses the principles and methods of operation of a water law in a state suffering from a shortage of water. Let us immediately clarify the concepts necessary in determining the scope of the problem. The concept of "water shortage" is now in widespread use in the whole world, and not particularly in arid countries. The expression has been used to describe a variety of situations among which we should differentiate. We will state that a water shortage can be expected in a particular society, where the water resources available to it are not sufficient to maintain the current level of consumption, or the level expected in the foreseeable future, and where these resources are insufficient for carrying out those development plans which are essential to the growth and advancement of the society. The concept must always be related to a particular society in a specific geographical region for otherwise it lacks all content. A particular region of a state may suffer from a shortage of water, while the water resources of the state as a whole are sufficient for its maintenance and development. A whole state with all its component regions may suffer from a water shortage which even the development of all its water resources, including large-scale water projects, exploitation of sewerage water, etc. cannot relieve to the extent of enabling it to carry out all its development plans, or removing the restriction of its natural growth. A whole state may suffer from a water shortage even when there are certain local surpluses of water. The extent of the problems dictates the means to be used to correct the situation, including the legal framework and regulations necessary.

The question arises what are the needs of the existing and expected future population of the state, or in other words what is that "public interest" mentioned in the water laws of many countries, according to which the water resources of the state should be planned and allocated. It is clear that this concept goes far beyond water matters, and in fact the satisfactory organisation and administration of water matters is a part of the "public interest".

We may say that it is that concentration and unification of all the national planning of all sectors of the society and economy of a particular state which has been adopted by the legislature, or by the administration (if the legislature has delegated this power to it). Concentration, unification and the fixing of priorities among different programmes do not yet exist in many states. It does not follow that the public interest does not exist in these states, but simply that official expression has not been given to it. The "public interest" is thus the supreme national plan which unifies all social, economic, security, political and sanitary considerations existing in a particular society, in order to achieve the maximum social and economic advancement of the state.

Water planning must be an instrument in the realisation of this supreme national plan, in whatever form it exists at each stage of the development of the state. In addition it must direct this national planning by collection of all the data on the water resources of the state and the possibilities for their exploitation by means of large-scale water projects or by other means such as water rationing, water pricing policy etc.

The water law is the means for carrying out water planning and thus indirectly for executing social and economic decisions relating to such matters and dispersion of population, types of settlement and the physical planning of the state.

If the wide powers that such a law must confer on the water administration are granted within a framework of general water planning, which is coordinated with the supreme national plan, then the exercise of discretion on the part of the water board will tend in the largest possible degree to be in the direction of the public interest, and it will be possible in this way to manage the water interests of the state in a planned, well-considered and consistent manner.

B. BASIC PRINCIPLES OF WATER LEGISLATION.

1. In planning the exploitation of the water resources of an arid country, all sources of water in the state should be treated as belonging to a single system, without regard to the traditional division between underground and surface water, etc., The administration of all the water affairs of the country should be in the hands of a single body responsible for dealing with all problems connected with water: the exploitation and development of water resources; drainage and flood prevention, water conservation, water measurement, determination of norms for the efficient and economical use of water.

This water-administration is responsible for the distribution of all the country's water resources, but it is clear that it is not for it to determine what use of water is in the best interests of the national economy and for the development of the country. If there is an overall development plan, it will be among the functions of the water administration to fix a water policy which will further the execution of this plan. We may assume that most countries do not have over-all development plans, even when they do have various partial plans and their policy-makers know the general trends which they wish to follow in the development of the country. In this state of affairs the water administration is faced with a difficult and responsible task - allocation of the available water resources in the public interest, without any clear directives as to what constitutes the public interest. The process is generally as follows. The water administration initiates the legislation for control of the water resources, legislation which gives it extensive powers, which in large measure enable it to dictate development policy for the whole state. If the water administration is given the right to divide the sources of water by suitable licensing provisions, in the absence of an official development plan, the principles adopted by this administration will determine the development of the economy.

However, to postpone water legislation in such a country until an overall development plan has been decided upon and to allow free withdrawal of water until such time, will lead to the destruction of water resources and the loss of an essential element for progress in any arid country developing at a modern pace.

In order to overcome this difficulty the water administration must be required to base its water policy on the existing development plans of the state. Such a policy will enable it to make its decisions on a uniform basis, and to avoid contradictory decisions in relation to water allocation. In other words a plan, even if only partial, which makes it possible to allocate water systematically and consistently among consumers and among different uses is preferable to complete absence of a plan, which leaves the state without any guiding principle in dealing with eachseparate request for a water ration. Undoubtedly in most existing states there is sufficient data for the preparation of an approved outline plan to serve as a directive as to the declared policy of the government. If details are lacking, it would be part of the function of the water administration to see that they were collected and collated by the bodies qualified to do this.

2. It appears from the above that a nation's water laws should provide the widest possible framework for the execution of policy within a framework of flexible directives. The various water uses should be specified in the law, but priorities among them should be fixed not by the law itself but by the administration, having regard for plans which will be drawn up from time to time. The water administration should have the widest discretion, to be based on all the factors affecting the public welfare, as expressed in the policy adopted by the government. However this discretion must be subject to legal supervision. The rights of the individual must be protected as far as possible, but they must not be allowed to prevent any action necessary for the development and advancement of the society and the economy. Water prices must be controlled, but market forces should be allowed to continue to operate as far as possible.

3. The Israeli legislation took into account this two-way effect. The law places wide authority and discretionary powers in the hands of the water commissioner - but requires that these powers be exercised only after careful consultation with representatives of the consumers and the water suppliers. For this purpose the law established a Water Board which must be consulted before the water administration authority reaches decisions in all major decisions on water policy. The majority of members of the Board are representatives of the public, the minority civil servants, whose membership serves to assure that there will be full coordination among government departments in carrying out water policy. In addition the law requires that before any decision directly affecting the essential interests of consumers and suppliers e.g. water prices, special levies on water, etc., is reached, the authorities must hold public hearings, to enable the general public to express opinions on these matters and to consider the views expressed by the public, before fixing and adopting the principles concerned.

The Israel legislation went even further in the matter by setting up a special tribunal to deal with water problems. The tribunal is composed of one professional judge and two representatives of the public selected by the judge from a list drawn up by the Minister of Agriculture. This tribunal has the power to review all ad-hoc decisions of the Water Commisioner. The most important of these relate to the refusal to grant licenses, and to the conditions of licenses. In this way the public participates in reviewing every decision of the Water Commission against which any interested party wishes to appeal. There is a right of appeal from this tribunal to the Supreme Court of the state. Thus effective judicial review of all administrative decisions relating to water is assured.

4. We will now go on to consider a further point connected with the above - the protection of existing rights. The law should protect as far as possible the rights which existed before its enactment, to the extent that use was made of these rights. A water right of which use is made is private property like any other private property, even when there is public ownership of the water itself. The law must acknowledge the existence of this property and as far as possible leave it in the hands of its current owners. On the other hand it is most appropriate to regard any water use as a use under the law, and to include rights which existed before the passing of the law within the licensing framework. If we start from the assumption that water resources require unified central control and maximum rational exploitation, no great importance is to be attached to the fact that a right was in existence before the passing of the law. In short, an existing right must be acknowledged, subject to the same restrictions as a right granted under the law i.e. it may be reduced, norms may be fixed for it or a change of source of supply required.

The revocation of a water right must in most cases be accompanied by suitable compensation. The only case where this is not true is where water rights are cut down as a consequence of rationing in a whole region, where the water resources are not sufficient to maintain the existing level of water use, and the state therefore decides on a particular water regime in order to safeguard the future of the region.

Israel's water legislation goes very far in the protection of existing rights. For instance a water right cannot be expropriated simply because the water is needed for a regional or even a national project. It is possible to expropriate the source of the water for this purpose, but the owner is entitled to the same quantity of water as before, either from the project or from some other source. In addition a right which existed before the law was passed cannot be transferred to another purpose or another use by some other person, even if this other use is more desirable and beneficial from the viewpoint of the national economy. (Preference of one right over another is allowed in the rationing zones mentioned above.) The

principle on which this approach is based is clear. The water law is not a planning law in itself, but an aid to national planning. If it was possible to expropriate water rights for the benefit of large-scale enterprises, or to give preference to certain water rights over others by means of the law, this would imply that planning of the national economy had been delegated to the water authority, a situation which is regarded as untenable. However once the national planning or planning in a certain specified sector is adopted by the legislature, water rights should be expropriated by the water administration within the framework of this planning.

5. In rationing zones less regard might be given for the rights of the individual. The reference is to regions in danger of social and economic collapse because of the exhaustion of water resources, exhaustion due to excessive withdrawals and not to seasonal or chance variations. Such a region must be protected from degeneration and destruction by much more stringent measures, likely to have an adverse effect on the rights of individuals, than would be appropriate in regions where the use of water resources is being planned for the future. In such a region the authorities must have the right to fix maximum quantities for various uses, to forbid certain uses altogether, and to determine priorities among uses. What is involved here is not planning of the national economy but preservation of the status as far as possible. In the payment of compensation the property holders adversely affected by these arrangements, the principles enumerated above are not to be followed since the exhaustion of water resources is due to the activities of the region itself and the arrangement is for the benefit of the inhabitants of the region. A sharp distinction must be made between rationing arrangements and planning on a regional or national scale for the development of new water resources, and the transfer of water from one region to another. Such projects are part of the water policy which serves to make possible the execution of the overall national economic plan. Decisions on such activities must be based on economic, security, social and administrative considerations. In this context the overall national plan adopted by the state may determine that a specific region suffering from an acute water shortage should not be developed any further; there may be scope for the transfer of population or for the transfer of certain water uses to other regions. Even though they arise from a certain state of the water supply, these are problems of overall planning, and the far-reaching decisions involved must be very carefully weighed in the light of the criteria mentioned above, as they influence the whole structure of the national economy. It is in the period before a final decision is reached that the emergency measures mentioned above are necessary.

There must be the fullest public participation in arriving at decisions which may shake the social and economic foundations of the regions affected. Before rationing ordinances are promulgated an extensive programme of public education must be undertaken, the public's views on the steps proposed must be heard, ways must be sought to minimise the damage to the property of individuals and the courts must be allowed to test the fairness of the allocations.

Even the best technical and economic plan cannot succeed if there is no public understanding of the nature and purpose of the steps proposed.

6. The last question to which we must give our attention is that of compensation for damage to property resulting from the administration of water policy. It is clear that if the setting up of a public water project will make it necessary to expropriate property (including water rights) full and fair damages should be paid, as is the case when establishing any other type of enterprise for the public purposes. In respect of payments of compensation in rationing zones, we have expressed our opinion above.

7. In any discussion of the principles on which water laws must be based, and whose execution the water administration must supervise on a national basis in a water scarce country, the question of water prices must be mentioned. Water, either as a commodity or a service, has a price. Its transport to a particular place involves costs. In a state with limited water resources, the price of water will be influenced by the fact that there is a shortage, particularly as water supply is generally a monopoly service. It is possible to maintain that market forces are the best guide to efficient and desirable water use (except perhaps in the case of drinking water). There are many economists who support this viewpoint, with certain reservations, but it is obvious that it is not appropriate to the conditions of a country which is faced with a water shortage. The allocation of water resources among the different sectors cannot be made on economic grounds alone, for social, security, psychological and political considerations deserve to be given no less weight than the economic ones. Thus water prices cannot be left to consumers and suppliers without supervision, in order to fix ceiling prices for certain uses. The desirable trend is that there should be intervention only when one of the parties requests the arbitration of the authorities. Another problem is that of water pricing for a large-scale regional or national project, where the cost of the water varies at the different points of supply. Moreover, in different parts of the country there may, for geographical and topographical reasons, be different water prices. In order to carry out the division of water resources among the different regions of the state, the water administration has to have the power to determine water prices so that it will be possible to fix prices within the ability to pay of the different sectors of the economy in different parts of the country. The legislation should limit the discretion of the water authorities in this matter and require that they take into account the economic viability of the water enterprises on the one hand, and the ability to pay of the various sectors and regions on the other. A water supply system, even if it is a public enterprise, should not be obliged to function at a loss, while a water price in excess of the ability to pay of the consumers of a particular sector will interfere with the realisation of the national development plan. These two principles together may lead to the dilemma of choice between a loss to the supplier and a price beyond the ability of the consumer to pay. To meet this dilemma the government must adopt an appropriate policy of subsidisation - by means of an equalisation fund as in the Israel law, or by some

other means, drawing on the national exchequer. However, this is not the place to discuss this complicated problem, which is deserving of special attention. It is sufficient to emphasise here that wherever water occupies a central place in the national development plans of a particular state, legal means must be established for the control of water prices.

C. PROBLEMS IN THE IMPLEMENTATION OF WATER LAW

1. Any water law involves considerable limitation of the freedom of the individual; this expresses itself in limiting individuals in the full enjoyment of their property, and in limiting private enterprise in the development and management ofprojects. A water law which requires a license from a central authority for the use of water, and fixes priorities among uses according to various criteria, without taking into account that the source of the water lies in or crosses a particular area of land, limits the rights of land-holders in their property. It may be assumed that in every country, prior to the passing of a modern water law, there were certain accepted practices which regulated the relations among landowners bordering a single source of surface water. However, regulations affecting ground water as well as surface water which sever the connection between water rights and ownership of land and require licensing are an innovation in most cases. This innovation, although it is essential in a water scarce country, is bound to come up against stiff opposition, from property-holders. The greatest difficulty is in gaining acceptance for the principle and in implementing the licensing system by means of the water law. It must be remembered that from the moment the law as proposed by us is passed, a person may no longer drill for water in his own land and use the water as he pleases, nor may he divert water from a river crossing his own land. These are rights which will not be relinquished easily, whatever the rational justification for their limitation. Thus it is natural that there will be opposition to the law from all sectors and only a water administration equipped with adequate data and detailed plans, carrying out a sensible programme of public education, will be able to get a comprehensive water law, capable of fulfilling the functions enumerated above, passed.

2. An additional problem to be mentioned in this context is the conflict between the existing economic and social framework andthe principles of a modern water law. The purpose of the law is to assure economical and efficient use of water, whereas in any society there are undoubtedly uses which are neither economical nor efficient. For instance, there might in a particular area be small holdings, which if farmed together by a single organisation, could increase the efficiency of water use; a region in which it would be reasonable to develop industry at the expense of agriculture, etc. etc. The water consumers involved will undoubtedly demand the continuance of their water rights, and so prevent the maximum exploitation of water resources. Much thought will have to be given to many criteria other than the economic, such as the desire to preserve a certain type of settlement or a certain way of life, dispersion of the population, preservation of natural beauty, etc. In other words, there is no automatic identity between the most desirable and the most economic use of water, for the economics is only one of the factors to be considered in overall planning, and the law must allow all factors to be taken into consideration.

D. THE STRUCTURE AND FUNCTION OF THE WATER ADMINISTRATION.

1. From the above the task of the water administration in a water scarce developing country becomes clear. It is a double task - the drafting of the water laws necessary to the stage and the administration of these laws after they are passed. In order to carry out these tasks the water authority must be an integrated body with all the professional skills and knowledge necessary for the drafting and securing the adaption of the law, and afterwards for its administration. It should not be required of the water administration that it collect and collate all the data necessary in creating a water policy, which is auxiliary to national planning. However, the water administration must have sufficient information and authority to formulate a water policy coordinated with national planning policy. For this purpose it must centralise statistical data, economic development plans for the various sectors, plans for the dispersion and forecasts of the future growth of population, and physical planning of the state. From this and much other data it must prepare plans for the allocation of the water resources of the state. These water resources include not only surface and ground water, but also the exploitation of sewerage water and sea water. This plan should carry much weight in decision-making, but it must not be forgotten that it is only one of a number of factors shaping the overall national plan. The law should guarantee that all development plans should be examined by the water administration, and should not be carried into practice without its approval. Since in most states exist only partial and uncoordinated plans of various governmental bodies, with no order of priority fixed among them, it is possible that each planning department will be interested in advancing its own plan; Lack of coordination will bring confusion and make it impossible to carry out any one of the plans. Water does not have to be the deciding factor, but it is one of the central factors which must be taken into consideration, so that it may be clear what the future holds for the project being examined. All the development plans must be concentrated in the hands of the water administration. Water allocation for any purpose will be carried out by means of licensing, taking account of present water use and existing rights in the region, and other development plans, in addition to hydrological considerations. Only in this way is it possible, in the absence of an over-all plan, to achieve a reasonably fair distribution of the water, and at least to avoid the creation of situations which will prevent the execution of a national plan in the future.

2. Without discussing in detail the structure of the water administration, it is clear that it must include professional units capable of collecting and processing data and of reaching conclusions both about the future (the development plan) and on an ad hoc basis. Every request for a water allocation must be examined both in the light of existing general plans and on its specific merits. The water administration must have the necessary knowledge to reach decisions at both these levels, and to justify its decisions to the public, and if necessary before the courts. The courts will weigh these decisions both in the light of national plans and in that of the

specific concrete facts before them in the particular case. In order to pass judgment they require a well-reasoned and carefully drawn up account of all the facts of the case and this must be provided by the water administration. The water administration requires a team of economists to examine the economic aspects of plans and to direct the use of water into efficient and economical channels by means of water pricing policy, subsidies and taxes. It requires a legal unit to supervise the execution of the law, for however well formulated a law may be and however comprehensive in its scope, it is not of much value if it is not enforced. The holder of a license who does not conform to its conditions and does not observe the norms and rules for efficient water use, undermines the purposes for which the law was passed. It is essential that the water administrator supervises the withdrawal and use of water on a national scale. This gives rise to many problems. Legal and administrative, but only a well implemented law can be of any benefit to people of the state.

E. CONCLUSION.

In conclusion it may be said that the water administration and the law which it administers, fulfill an important function in the development of the state, and in maintaining its very existence. Without a highly developed water administration with wide powers, the planned development of a state is not possible. Even so, it must be emphasised that the water administration is only a single link in the chain of planning of a developing country. Possibly it is in larger measure the executive arm of the planners, but particularly because of this care must be taken that it does not become an independent planning force, determining the direction of development for it is not the economy of the country alone which is being discussed, but the development of that economy with its far-reaching effects on the social framework, way of life, and achievement of political and social aims. Certainly the water administration should not be the decisive force in these fields, but only a means of testing the feasibility of execution of plans proposed, and an instrument for their achievement.

The Israeli Water Law of 1959, now being implemented by the Water Commission of Israel embodies the principles discussed in this paper. The experience of these 3 years gives good cause for belief in the soundness and applicability of these principles.

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FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A. 3. 4. 1

South Africa

REDUCTION OF EVAPORATION LOSSES : A SUMMARY OF RESULTS OF TESTS IN SOUTH AFRICA

By D. F. ROBERTS, B. A., B. Sc.,
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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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REDUCTION OF EVAPORATION LOSSES. A. 3.4.1

A SUMMARY OF RESULTS OF TESTS IN SOUTH AFRICA.

by D.F. ROBERTS, B.A., B.Sc., HYDROLOGICAL RESEARCH DIVISION : DEPARTMENT OF WATER AFFAIRS.

1. INTRODUCTION.

Preliminary tests were carried out at the Hydrological Research Division's experimental station in Pretoria using an existing battery of evaporation pans of various sizes and these were followed by tests on natural bodies of water situated in the semi-arid area near Kimberley.

2. TESTS OF PELLETS OF CETYL ALCOHOL.

Pellets of practically pure Cetyl Alcohol, manufactured to meet the specification of the C.S.I.R.O. of Australia for use in the raft method were tested by scattering various quantities on the surface of the water. The doses varied from sufficient alcohol to produce two monolayers up to sufficient to produce two thousand monolayers but in no case could any reduction in evaporation be detected.

The pellets were next tested in a standard raft (built in Australia according to the C.S.I.R.O. specification) in one of two 14 feet diameter evaporation pans 3 feet deep, the other pan being used as the control. The raft received a full charge of 2¼ lbs of pellets and (as it was floating on an area of 155 square feet instead of the 40,000 square feet for which it was designed) it should have produced a marked reduction in evaporation, but none was observed although the test continued for 16 days.

In order to test the quality of the Cetyl Alcohol, two grams of the pellets were dissolved in petrol and sprayed on the water in the control pan. During the next 48 hours the reduction of evaporation was 45 percent indicating that the quality was satisfactory. An examination of the floating pellets under a magnifying glass showed that they had been drawn completely under water by surface tension, thus preventing the release of molecules of alcohol so that no film could be formed.

3. APPLICATION OF ALCOHOL IN DIFFERENT STATES.

Cetyl Alcohol was applied in various states such as, large pellets, small pellets, flakes, fine powder and in solution, each set of tests being repeated several times, with the following results.

(a) The pellets failed to reduce evaporation.

(b) The flakes produced an average reduction of 17 percent over the first 48 hours.

(c) The powder and the solution behaved similarly and produced an average reduction of 40 percent, over the first 48 hours.

(d) In all cases, after 48 hours the rate of reduction fell and reached zero at four days after the application of the alcohol.

4. TESTS OF DIFFERENT TYPES OF FATTY ALCOHOL.

The relative efficiencies of several samples of pure cetyl alcohol (C.16) and commercial mixtures (C16-C18) were tested but very little difference in the behaviour was found, any small differences being in favour of the mixtures. The alcohol was applied as a powder or in solution.

5. THE EFFECT OF DAILY DOSING.

The tests mentioned in paragraph 3 showed that efficiencies fell off after 48 hours. The effect of daily doses was tested by applying alcohol (sufficient for 70 monolayers) each morning for nine days. During this test the rate of reduction remained fairly constant at an average of 43 percent.

6. FILM PRESSURE MEASUREMENTS.

Throughout these tests film pressures were measured by a light balance (using the ring method of measuring surface tension) which could be held in the hand while making measurements. This balance (The Roberts Film Pressure Balance) proved to be sufficiently accurate for its purpose, giving results within 5 dynes per cm. when used from a boat or on rippled water ; when used on the evaporation pans the results were within 2 dynes per cm. while in the laboratory results were within half a dyne/cm. Measurements in the evaporation pans showed that pressures of 35 to 40 dynes per cm. could be built up within an hour when using powder. These pressures persisted for 24 hours or so and produced a reduction of evaporation of about 45 percent. The pressures dropped to 20 dynes per cm. within 4 days and at this pressure there was no reduction of evaporation.

7. PRELIMINARY CONCLUSIONS.

At the completion of the preliminary tests at the experimental station the following conclusions were reached.

(a) The fatty alcohol should be applied as a finely divided powder or in solution.

(b) A fatty alcohol mixture (C16-C18) is as good as pure Cetyl Alcohol.

(c) Daily or continuous dosing is necessary.

(d) The maximum reduction of evaporation that can be expected under the best conditions is 45 percent if a fully compressed film is maintained continuously over the whole surface of the water.

8. FIELD TESTS.

Most of the field tests were carried out on a body of water 23 acres in extent which had been created by filling a dry natural depression. Reduction of evaporation rates could not be determined so the tests were limited to observing the behaviour of the films and the measurement of film pressures. Two of the tests are described.

9. THE EFFECT OF WIND ON A FILM.

A small quantity of alcohol in solution was sprinkled on the water near the up-wind edge of the depression. This formed an "island" of film which could be seen by its glassy appearance. Under the influence of the wind (600 feet per minute) the "island" moved slowly

across the water and it was observed that

(a) the leading edge moved at 30 feet per minute

(b) the trailing edge moved at 15 feet per minute

(c) the lateral spread was 3 feet per minute each way.

Film pressure measurement at the down wind edge of the water gave the following results

(a) Immediately after the arrival of the leading edge the pressure rose from 7 to 43 dynes per cm.

(b) Ten minutes later the pressure had dropped to 20 dynes/cm.

(c) Half an hour later all traces of the film had disappeared except for a line of spongy alcohol washed up on the beach indicating that most of the solution had been blown ashore before the solvent could evaporate.

10. FIELD TESTS WITH POWDER.

In one of these tests 90 lbs of powder were scattered over the whole area in very calm weather. On the following morning it was found that a film with pressures exceeding 25 dynes per cm. covered 22 percent of the surface, that 28 percent was covered by a film with pressure less than 25 dynes per cm. while the balance (50%) registered negligible pressures. The next morning, under the influence of a light breeze(one mile per hour) the film had moved across the water to the other side and had been reduced in area. This test indicated the difficulty in establishing a satisfactory cover even in calm weather, while other tests showed that films were blown off the water rapidly during windy weather.

11. FINAL CONCLUSIONS.

(a) Wind moves the film to the shore line and destroys it.

(b) There is very little lateral spread.

(c) The film does not spread against the wind.

(d) The whole of the film is never fully compressed.

(e) It is very difficult and costly to cover a natural body of water completely with a fully developed film so that there is little possibility of producing reductions of evaporation approaching any way near the 45 percent produced in the evaporation pans at the experimental station.

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Agenda Item : A. 5. 1. 4

United Kingdom

TRAINING OF GEOLOGISTS AND GEOPHYSICISTS IN THE UNITED KINGDOM FOR SERVICE IN THE UNDERDEVELOPED COUNTRIES

By K. C. DUNHAM, F. R. S.,
Professor of Geology in the University of Durham

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TRAINING OF GEOLOGISTS AND GEOPHYSICISTS IN THE UNITED KINGDOM FOR SERVICE IN THE UNDERDEVELOPED COUNTRIES

By K.C. DUNHAM, F.R.S.

Professor of Geology in the University of Durham

1. The Need for the Geologist.- In the less developed areas the need for geologists with a broad background and an adequate field training is among the most fundamental of technological requirements. The geologist's work is essential in the efficient search for underground water supplies and in the proper exploitation of surface water. Upon him depends the discovery of fuels - coal, oil, uranium - and the execution of prospecting programmes for mineral resources of all kinds; iron ore, the base metals, gold, platinum, the raw materials for fertilisers, even for building come within his scope. The siting of industry and the development of towns alike depend in the last analysis upon the geology.

The desirability of an exact knowledge of the bedrock and of the superficial deposits resting upon it was recognised at an early stage of the Industrial Revolution in Europe and all highly developed countries have set up permanent Geological Survey organisations, the first of its kind being the Geological Survey of Great Britain, founded by Sir Henry de la Beche in 1835. It is important to emphasise that geological work which in the long run is adequate to a nation's developing needs cannot be carried out on an ad hoc basis. The systematic mapping, on a proper scale, of the rock and drift outcrops, and the interpretation of these in terms of geological structure and history is the basis upon which all else rests. Exposure is usually such that a large element of intelligent interpretation necessarily enters into this process, and for this reason the employment of technicians without an adequate training in the sci ence to do the field mapping is neither possible nor desirable. The work in the field needs to be supported by laboratory facilities for the study of the rocks and minerals discovered; here again, specialist training is necessary

The important place of the geologist in a developing country has been recognised by the large expansion of the United States Geological Survey in the early years of the present century, and more recently by the creation of the huge geological organisations

of the U.S.S.R., with a Minister of Geology at their head. In the overseas territories for which Britain has been responsible, Geological Surveys were set up, and these have been expanded since 1945 with financial aid from the Colonial Development and Welfare fund. A highly organised centre for research on Overseas Geology has been created in London. With the achievement of independent status the need for continued improvement of the Geological Surveys certainly becomes more, not less essential.

In the special field of metalliferous mineral deposits there are now few regions of our planet which have not been examined by prospectors. Even in the least developed areas, the obvious outcropping deposits are often known though economic factors may have delayed exploitation. Future discovery depends to an ever-increasing extent upon the application of sophisticated scientific methods. The exploitation of orebodies discovered also calls for specialised geological techniques.

2. The role of the Geophysicist.- Geological field surveying depends upon direct observation of outcrops or artificial exposures, coupled with the use of drilling. Further information about geological structure can however be obtained by the use of indirect physical measurements such as the magnetic field, the electrical properties of concealed rocks, and the gravitational attraction they exert. The geophysicist, who makes these measurements, has become an essential member of Geological Survey parties. Particular practical success has been achieved, as is now well known, in the delineation of structures favourable for petroleum accumulation, but geophysical methods have also been applied with good results to problems of water-supply, and in the search for metal deposits.

There is, then, likely to be a demand for increasing numbers of geologists and geophysicists for service in the less developed areas. The problem is, where are they to be found?

3. The United Kingdom contribution.- Since 1945 the British universities have more than doubled in size, and an increasing pace of expansion which includes the foundation of at least six new universities can be forseen for some years to come. Geology, which has been the subject of teaching and research in the older universities from the earliest days of the science, is taught at almost all the existing institutions.

The annual output of graduates having a first degree with Honours in Geology is now of the order of 200 (vide Williams, D, 1960, p.602) while about 100 per year proceed to a postgraduate degree.

Within Great Britain there is scope for the employment of only a small proportion of this output, and as keen young men come forward, as they do, in ever increasing numbers, wishing to embrace Geology as a career, their university teachers can only tell them

that their future is likely to lie in employment overseas. Many students take up the subject with this intention. There is, indeed, a long tradition for investigation of geology in every part of the world by British-trained geologists both on behalf of governments and private enterprise.

The primary purpose of this paper is, therefore, to point out that the United Kingdom can offer a substantial contribution of trained geologists for service in the less developed areas of the world. It is worth recalling that the staff of nearly every British university geology department includes men who have served under the difficult conditions of the African forest, the arctic waste or the tropical desert, and who understand not only the technical but also the personal qualities required for success in this work.

Moreover, the British universities not only train U.K. nationals for this work, but they also welcome students from overseas. These may be supported by their governments, or by various organisations such as the British Council. Both at undergraduate and at postgraduate level, room can be found as expansion proceeds for more men from abroad, who intend to go back to their countries qualified as geologists.

It is suggested, therefore, that the present time is a particularly opportune one for the United Kingdom to assist the underdeveloped countries by providing trained British geologists, and by training their own nationals. It is clear that trained geologists are not likely to be produced in numbers adequate to meet the needs of the situation in most of the countries with which the present Conference is concerned; Britain might be said at present to possess spare capacity to meet part of the need, not only for Survey, Mining and Oil Geologists, but also for university teachers able to help in the new universities of the emergent countries.

4. Pre-University Requirements.- Admission to undergraduate status depends upon the possession of qualifications which are reasonably similar for all English universities. The normal requirement is to have passed the school examination known as the General Certificate of Education (or its equivalent) in five or six subjects, of which at least two must be at the Advanced Level. English and a language other than English must be included but for candidates wishing to enter Geology, these are usually taken at Ordinary Level. Most university geology departments prefer the Advanced Level subjects to be selected from Physics, Chemistry, Mathematics or Biology. No department (to my knowledge) requires a previous knowledge of geology, but some will accept an Advanced Level pass in the subject instead of one of four mentioned above. A good level of attainment in natural science is thus expected before entry; in Mathematics, for example, the Advanced Level requires a knowledge of the calculus as far as simple integration by parts, changes of variables and the use of partial fractions, as well as co-ordinate geometry as far as the hyperbola. In Physics, the requirements include the simple Kinetic

theory of solids, liquids and gases; a qualitative treatment of plane polarised light; refraction at a spherical interface; electrostatics and an elementary knowledge of nuclear theory. Chemistry at Advanced Level covers not only systematic inorganic chemistry in the light of the periodic table, and organic chemistry as far as benzene; but also the basic facts of physical chemistry and their applications.

For admission to a post-graduate school, the normal expectation is that the candidate will possess not less than a second class honours degree or its equivalent. Many departments welcome men who have had several years professional experience after taking their first degree. Many men go to another university for their post-graduate studies and at this level, exchanges with European and American universities now take place.

5. The first degree.- In Britain the basic training of geologists for their profession is carried out while they are undergraduate candidates for the B.A. or B.Sc. degree. A minimum of three years or a maximum of four years' residence is required at this stage, depending upon the candidate's attainments at entry, and upon the general practice of the university. Usually two subjects other than geology are studied at the university to first or second year standard; at Cambridge, three subjects (of which geology is one, and mineralogy and petrology one) are read for two years to reach the Natural Sciences Tripos part I; at Oxford, on the other hand, no subject other than the main one need be read.

As already noted, no previous knowledge of geology is assumed. The early stages of the course are usually devoted to the material of which the rocks are built - that is, the rock-forming minerals - and their properties, crystal morphology, composition and identification. The use of stereograms is introduced at this stage, not only as an aid to crystallography but to induce a capacity to think in three dimensions. Geological processes are meanwhile considered, using the Principle of Uniformity as a basis of interpretation. Stratigraphy, basic to most geology, follows naturally and the small British islands offer an almost unique setting for this side of the teaching, for almost every stage from Cambrian to Cainozoic can be seen within the compass of a day's journey and four of the five Palaeozoic systems in world-wide use were named for British localities. Systematic palaeontology comes in here, with a modern emphasis on genetic studies on the one hand, and the refinement of dating by fossils on the other. The introductory mineralogy gives place to more sophisticated methods of identification; optical, x-ray, diffractometer, differential thermal analysis and meanwhile the serious study of microscopical petrography leads to theoretical petrology, with an emphasis on the application of physico-chemical and thermodynamic principles. Other work in the laboratory includes the study of geological maps, and at some universities introductory courses in geochemistry and geophysics. Lecture courses and demonstrations on the economic mineral deposits are offered by some though not all departments; there are still those who maintain that science should be pursued

for its own sake and that, in any case, a good basic training in geology is adequate to enable any problem posed by a valuable mineral deposit to be solved. There are others who find a major interest in the special problems of the search for useful minerals and therefore include extended courses on this subject in their curricula.

Meanwhile, during the vacations (which cover about five months of the year) field training is begun. The main object, apart from enabling the student to see the relationships in space of the rocks and their appearances in the field, is to teach him to record accurately on a map what he sees. The British Ordnance Survey 6-inch/mile (1:10560) maps are usually employed for base maps at this stage but some acquaintance with aerial photographs (which the geologist may expect to use as base maps in the less developed territories) is gained. At Nottingham, Imperial College London and Edinburgh special training in photogrammetry is available. Many departments subsequently allocate the student an area to map and to study in full detail as part of the work of his course, two or three months being devoted to this. Some students also avail themselves of the various opportunities offered by organisations such as I.A.S.T.E. to work in mines etc. abroad for a month or two.

The final examination covers the whole subject and usually consists of four or five theoretical papers and about 9-12 hours of practical examination. The results are classified, the system varying a little from university to university; but uniformity of standard for the first and second class is attempted by the use of external examiners from other universities.

Some students enter professional work at this stage; their age upon graduation is usually in the range 21-23; their physical stamina is often at its best and many show a contagious enthusiasm for work under difficult conditions.

6. Postgraduate degrees.- Further study in the university leads to the Master's degree, to a diploma such as the Diploma of the Imperial College (D.I.C.) of similar status to the M.Sc., or to the Ph.D. (D.Phil. at Oxford). Candidates for the two first-mentioned may be required to take formal courses of instruction in specialised branches of the subject, and the action of the Department of Scientific and Industrial Research in financing Advanced Courses has led to the setting up of such courses for example, in Mining Geology and Engineering Geology at the Imperial College, London; in Applied Geophysics at Imperial College, at Birmingham and at Durham; in Geochemistry at Oxford, and in Micropalaeontology at University College, London to mention only a few. Some original work may be required as part of the Master's degree, which takes one or two years to achieve.

For the Ph.D., the admission requirement is normally a good honours degree (i.e. Class I or high Class II); it is not essential to have taken an M.Sc. The three years residence required by most

universities for this degree is devoted to training in the methods of research, and to original investigation, working with an individual supervisor. Students are encouraged to choose their own problems; there is an increasing tendency to carry out field studies, where the these form part of the project, abroad. The prospect of employing candidates for the Ph.D. to map selected parts of the less developed territories and to bring their rocks to universities in the U.K. for laboratory study though it has sometimes been done deserves more consideration than it has so far had; it would lead to close links between university staff, students and the underdeveloped territories which could be beneficial to all the interests involved, while involving only small expenditures.

Geophysicists receive their basic training in a Geology or a Physics department, but their professional training is normally carried out at the postgraduate stage. Facilities for research exist in the Department of Geodesy and Geophysics at Cambridge; systematic practical training is provided at Imperial College, London, at Birmingham and Durham where there are, or shortly will be, sub-departments of Geophysics; the Physics department at Newcastle offers an advanced Course in Pure Geophysics, teaching and research is also carried on at Glasgow, Liverpool and in the Mining Department at Leeds. The relative emphasis on field studies as against theoretical interpretation varies among these institutions.

7. Conclusions.- (a) The United Kingdom is in a position to provide trained and experienced geologists and geophysicists for service in the less developed areas; (b) Training facilities are becoming available in Britain on an expanding scale and capacity exists to train nationals from the underdeveloped countries as well as additional U.K. personnel for this service. (c) Laboratory facilities of the most modern kind are available at the Overseas Geological Surveys centre in London, and at many of the British universities to support field work carried out in the less developed areas of the world.

8. References.

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MAPPING AND SURVEYING PRACTICES ADAPTED TO USE IN LESS DEVELOPED AREAS

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A.1 - MAPPING AND SURVEYING PRACTICES ADAPTED TO USE IN LESS DEVELOPED AREAS

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1. Introduction.

Nowadays the production of maps in less developed as well as in industrialized countries is based on the use of airphotographs. Consequently this paper will deal only with photogrammetric methods. The possible speed of production of maps and especially the use which can be made of the photograph as such with its abundance of information make that aerial survey becomes an indispensable tool for the execution of development programs.

Technical services when carrying out for instance engineering or agricultural projects need maps of different scale and precision . The cost of surveys in general represent only a very small percentage of the execution of such projects. There are many examples of waste of money caused by insufficient knowledge of the data which influence the project or its execution. Unfortunately administrative authorities too often consider the cost of surveys as a kind of non-productive expense, which must be reduced as much as possible. This is in particular true for general topographic maps of the country. These maps, originally surveyed in European countries for military purposes, are playing at present a dominant role in civil administration and technical services. Their scales must be adapted to the stage of development of a country and should not be larger than needed in the next 10 years, knowing that the larger the scale, the shorter the interval for resurveying in order to keep the map up to date.

These topographic maps are not only necessary to represent the geography of the country for a wide variety of purposes, but they are also the basis for topical maps of different character, such as geological, soils- and vegetation maps (see par. 6).

A very special service using maps is that for land registration (cadastral administration). Although many cadastral authorities are still hesitating about the application of photogrammetry to cadastral surveys we will show in par. 5 that airphotography can be not only a great help, but even the only tool which enables the responsible authorities in development countries to establish a reliable cadastral administration within a reasonable time.

All photogrammetrically produced maps others than topical maps can be divided into three groups depending on the proportion between the scale of photography and that of the map.

a. geographical maps 1:100,000 to 1:250,000
   enlargement 1:0,8 to 1:0,2

b. topographical maps 1:10,000 to 1:50,000
enlargement 1:4 to 1:0,8

c. technical and cadastral maps 1:1000 to 1:5000
enlargement 1:8 to 1:3.

This division into groups is based on the difference between graphical photogrammetric procedures for different values of the enlargement from photograph to map. Assuming a standard deviation (s.d.) of 160 micron in the manuscript (before reproduction) the s.d. in the position of a point in the photograph can for each of the three groups be between:

a. 200 and 800 microns
b. 40 and 200 microns
c. 20 and 50 microns

This shows that the requirements of precision for the plotting instruments and for the coordinates of passpoints are so different, that different procedures are justified.

Besides the graphical methods also numerical methods using comparators and digital computors are recently being applied to high precision problems such as cadastral surveys where the tolerance for the s.d. is 20 micron or less. In paragraph 7 : "Modern tools in less developed areas" the consequences of such methods will be discussed.

Par. 2. Determination of ground control points by airsurvey methods with a minimum of ground survey.

Almost everywhere field work is more expensive than office work and takes more time for comparable results. The consequence is that we find a continuous effort to replace ground survey needed for the determination of the necessary control in each photograph by other methods such as:

a. the classical aerial triangulation carried out either in universal plotting machines or in stereocomparators where highspeed computors and programmes are available;
b. the use of special equipment in the plane and in some cases also on the ground for the determination of the position of the exposure in space and of the inclination of the optical axis of the camera;
c. A combination of the methods a) and b).

Especially this combination considerably reduces the necessary ground survey, even for medium scale topographic surveys.
In the following part of this paragraph some characteristics of each of these methods is described and their application will be treated in paragraphs 3, 4 and 5.

a). Aerial triangulation.

When working in two shifts of 7 hours each the yearly triangulation capacity of one universal plotting machine with 260 working days lies between 2500 and 3000 pairs. In the stereocomparator the capacity will be between 5000 and 6000 pairs. To this must be added, however, the cost of computation of strip coordinates from plate coordinates. The cost of this will be, in a computor of moderate capacity for the same 6000 pairs which can be produced by the analogue plotter in about 30.000 minutes of $ 0,45 = 13.500.- . Whether the analytical method will be more favourable than the classical method depends therefore on the level of the wages and amortization of a second universal plotter with two operators who would raise the production to the same 6000 pairs. Assuming the amortization of the stereocomparator 1,5 x as high as that of the universal plotter there remain about $ 3500.- for the amortization of the 2nd plotter. This amount leaves for the two operators $ 10.000.- which in many countries will be sufficient. This computation shows that there is not much difference in cost between

the two methods. Therefore for less developed areas where the use of sensitive equipment is anyhow risky, we recommend for aerial triangulation the application of the classical method. This is especially valid for those countries where the number of pairs to be measured is smaller than 3000 per year and the high cost of the comparator can be amortized only over half its full capacity. Yet this instrument cannot, like a universal plotter. be used also for other purposes than aerial triangulation.

There are several survey problems where the heights are either not needed (cadastral maps) or where the requirements are out of proportion to those for planimetry and consequently only ground levelling can do (irrigation etc.). Then the planimetry can be determined by means of the well known slotted templet method if low absolute precision is sufficient. The use of the numerical radial triangulator is a cheap method which gives a high precision specially if the photographs are taken with a camera in a stabilized mount*(1).

The cost of a precision radial triangulator lies between 12 and 15% of that of a universal plotter and the time for observation is 50 to 60% of that needed for measurement of a pair in such a plotter assuming no more than the normal 9 points in each model. A larger number of points per pair decreases the difference in time in favour of the universal plotter. A disadvantage is that so far no mechanical or electronic registration of the readings is available. For adjustment of the rhomboids and computation of strip coordinates $\frac{1}{2}$ hour per pair more is needed than for the strip coordinates from a triangulation in space in a universal plotter. An easier and faster method for this, however, is developed by F. E. Ackermann*(2).

One of the major problems in aerial triangulation in common to each of the three methods mentioned before, is the adjustment of the observations. There exist several methods for the computation of strips. A usual method is to have full ground control of a pair at one end and two points at the other end and in the middle of the strip.

The graphical method of adjustment, called after Zarzycki, derives correction graphs for X, Y and Z-coordinates from the discrepancies in these known points. The same method can be applied numerically in case an electronic computer is available. In that case, however, the least square adjustment method for heights and planimetry with arbitrary positions of the control points as published by Ackermann*(3) is to be preferred.

It is obvious, that all separate adjustments of the strips of a block, each neglecting the many conditions for equal coordinates of the common points, require more ground control than a method of block adjustment which takes these conditions into account. Consequently this block adjustment is at present one of the major problems in photogrammetry. The difficulty is that the adjustment of a block of 10 strips of 20 models requires the solving of $10 \times 20 \times 4 = 800$ normal equations for planimetry only. This requires either the combination of a considerable number of pairs to units, which makes it to an iteration procedure, or a very powerful computer. At present research is carried out in both directions but for less developed areas none of the two can be recommended. Already the small number of blocks which must be adjusted per year does not justify participation in these experiments.

*(1) Van der Weele, A. J. - The precision of Radial Triangulation.
I. T. C. Publications, A9, 1962, Delft.

(2) Ackermann, F. E. - On the adjustment of rhomboids in radial triangulation.
Photogrammetria 1959-60 p. 81-89, Argus, Amsterdam.

(3) Ackermann, F. E. - A procedure for analytical strip adjustment.
I. T. C. Publications, A17, 1962, Delft.

Several mechanical methods of adjustment of blocks are proposed which partly found application. The socalled stereotemplet method*(4) which is popular in the USA needs orientation of the pairs and elimination of relief displacement. It is an improved slotted templet method which yields planimetric coordinates with a precision which depends largely on the scale of the templets.

Another method was developed in Delft*(5). Square sections consisting of a number of models e.g. 3 x 6 = 18 models are formed. Two templets are made of each of these sections at the scale of the map and a kind of stereo-templet triangulation is carried out.

This method was a forerunner of and was surpassed by Dr. Jerie's Analogue Computer developed in the I.T.C. after 1956. Stimulated by the method of Massus d'Autume for the adjustment of heights at the Institut Géographique National de Paris*(6), Dr. Jerie of the Delft ITC in 1956 started with efforts which in 1957 resulted in the design of his analogue computer*(7). With this equipment a least square adjustment of a block can be carried out separately for planimetry and for height. The basic difference with Massu d'Autumes method for height is that Jerie brought into his device the possibility to have residual errors.
No real least square adjustment is possible without the realisation of residual errors. The same was necessary for the adjustment of planimetric coordinates. This requirement was fulfilled in both cases by the use of adequate springs. The basic principle for the adjustment of the planimetry is furthermore the introduction of the discrepancies in the tiepoints between the four surrounding models on a much larger scale than that of the templets, representing the planimetric position. This fact, combined with a fast iteration procedure results in an adjustment system which gives about the same precision as an entirely analytical solution with several hundreds of linear normal equations.

Its advantages are the following:

a) Personnel with only technicians education can carry out the adjustment with the use of this simple equipment and a desk computer.
b) For blocks of 12 strips of 24 models each the necessary ground control for planimetry is 4 points at the corners and 1 point in the middle of each edge of the square block and for height three traverses of height surveys at the ends and in the middle of the strips.
c) Instead of 2 pairs, for surveys of less precision sections can consist of 2 x 4 or 3 x 6 pairs in order to master larger blocks with the same equipment at the cost of a somewhat reduced but still sufficient precision.
d) The time required for the adjustment of planimetry and height by experienced operators using sections of two models is between 2 and 2,5 hour per model.
e) With the use of good observations of the models carried out in universal precision plotters a s.d. in the planimetric position of between 0,02 and 0,04 mm in the plane of the negative is to be expected almost regardless of the scale of photography. This value for the relative errors (discrepancies in the tiepoints) is about half the value of the absolute error. The s.d. of the absolute values of heights is then between 0,025% and 0,035% of the flying height during exposure*(8).

*(4) Scher, Martin B. - Stereotemplet triangulation. Photogrammetric Engineering 1955, p. 655 - 664.

(5) Van der Weele, A.J. - Rational adjustment of blocks in Aerial Triangulation. Photogrammetria 1955-56, p. 306-310, Argus, Amsterdam.

(6) I.G.N. L'aerotriangulation spatiale à l'Institut Géographique National. Communication N. 3: Sur un nouveau procédé de compensation des cheminement photogrammétriques. International Archives of Photogrammetry Vol. XI, Argus, Amsterdam.

(7) Jerie, H.G. - Block adjustment by means of analogue computers. Photogrammetria 1957-58, p. 161 - 176.

(8) Waldhäusl, P. - Height adjustment by the ITC-Jerie method. Photogrammetria 1959-60, p. 29-37, Argus, Amsterdam.

Consequently it is not surprising that for the solution of the problem of correct block adjustment with economizing of ground survey many of the less developed countries use this analogue computer.

Another important problem regarding the computation and adjustment is how to deal with the so-called auxiliary data obtained during exposure such as APR tilt and tip from solar camera or horizon camera etc. How old the use of horizon camera and statoscope may be the method which gives the maximum benefit of these data is still a subject of theoretical and practical research.

Par. 3. Production of geographical and reconnaissance maps 1:100,000 to 1:250,000.

a). General.

There are still considerable parts of the world which are entirely unmapped or which are covered only by classical reconnaissance maps compiled from route surveys of travellers. Such maps have a low absolute precision and the relative accuracy is not homogeneous. The first step to improve existing maps is the use of airphotographs in order to obtain topographic details in areas where the traveller has never passed.

A better product, however, is obtained by starting the construction of a new map from scratch applying the most modern methods. Even then different stages of perfection can be reached. The first possibility is to produce smallscale geographical maps without any representation of height. A second step is to derive from the air photographs the land forms and represent these either by form lines or by shading. If also the planimetry has a very poor precision, a coordinate grid on the map will perhaps be indicated in such a way that this becomes evident.

There are cases where at present photogrammetry makes it possible to produce geographical maps in a scale 1:250,000 better and faster/by means of compilation from existing maps. In particular the high altitude photography, taken with modern lenses in scales 1:100,000 and smaller, in combination with control derived from existing larger scale maps, enables the /than service to produce a geographical map which is up-to-date, also of those areas where the medium scale topographic maps are not complete or out-of-date. This development makes the production of geographical maps by photogrammetric procedures, independent from existing maps, more and more important.

b). Photography.

By using the modern super wide angle camera photography becomes possible in the scales between 1:70,000 and 1:100,000 with the use of normal airplanes. These scales are smaller than the usual 1:50,000 made with 6" cameras, but are entirely sufficient.

It is strongly recommended to use a stabilized mount. If this is impossible other tools for the determination of the inclination of the optical axis (horizon camera or solar periscope) can be used. Furthermore, this kind of survey should no more be carried out without APR as will be explained in 3 c.

In areas where reconnaissance surveys of natural resources must be carried out with the use of these small scale photographs it is recommended to take photographs at the same time with a second camera having a focal distance of 12". This strip in the scale of about 1:30,000, although only covering isolated small strips, can be used as a key for the interpretation of the photographs 1:100,000.

c). Control.

Control for planimetry and for height are different problems, as for these surveys no aerial triangulation in space will be necessary if certain precautions are taken.

The planimetric control can be obtained from a combination of slotted templet and block adjustment with analogue or electronic computer. For the map 1:250,000 with photography 1:80,000 blocks of 30 strips of 60 models each can be mastered in this way. Such a block is 400 x 400 km and no more groundsurvey for planimetry is required than a number of 8 astrofixes around the edges of the block. These astrofixes are at such long distances (150 à 200 km) that the deviations of the plumbline will do not much harm to the relative precision. Tellurometer traverses around the block are even better. In the centre of the block no planimetric control points are needed.

The control for height can be derived from the combination of APR and camera orientation equipment (horizon camera etc.). For maps in the scale 1:100,000 with contours of 100 ft. the APR can provide us with a satisfactory precision of height in the flightline and also of the inclination of the airbase. For the determination of the tilt perpendicular to the flightline the horizon camera is the cheapest solution (after the solar periscope). The stabilization of the camera mount which can give the same precision as these two, is still too expensive and that which is good enough to improve for instance the slotted templet, is not sufficient for this purpose. Another method is to fly cross-strips at regular, rather short mutual distances or to fly low APR strips in the lateral overlap of the photographic strips. This method, too, is more expensive than the use of the said camera orientation equipment. Regarding ground control for height it is sufficient to determine a number of points in the area by precise aneroid observations to check the APR regularly during its flight.

One of the important consequences of this photogrammetric method is that large areas can be mapped without the execution of a time consuming and costly previous primary geodetic triangulation.

Whether other expensive methods should be applied to the survey of geographical maps in less developed areas is doubtful. After World War II electronic methods such as Shoran, Hiran, Decca were used to determine a primary network of points by line-crossing and trilateration (Canada). By the same methods also planimetric coordinates can be obtained of each exposure of a strip of airphotographs. This method was applied to some large projects carried out for the account of US authorities. Compared to the methods as described in par. 2, this method is too expensive and is at present abandoned in those cases where economic considerations are preponderate and where it is preferred to have the survey done by the national manpower of less developed countries.

d). Plotting of the manuscript.

Regarding methods and instruments a wide variety is in use and more research should be carried out with respect to the economy. Very few figures about time of production of these maps have been published and due to the great difference in the type of terrain, individual figures have not much statistical value. The scale of the manuscript is normally twice as large as that of the published map which simplifies the task of the draftsman.
For the method of plotting one must distinguish between real topographic maps and maps with planimetry only. For the latter tracing of the rectified negative is recommended. If the manuscript scale is about the same as that of the photographs a sketchmaster can be used as long as the terrain is only smoothly roling. For plotting of planimetry of terrain with greater difference in altitude, a radial line plotter can render good services. With all these instruments four controlpoints in each pair are required for easy and reliable work.

In case contours must be plotted we recommend the use of so-called third order instruments, such as Drobychew topographic stereometer, Stereotope, Santoni Stereomicrometer or the French Stereoflexe. For these instruments we need in general known height and planimetry of 4 controlpoints in the corners of each model. If aerial triangulation was carried out, these data will be available. Since we however explained that surveys for these maps do not need this in case APR and camera orientation equipment (horizon camera etc.) are used it will then be necessary to develop a system which allows to impose those data directly to these instruments.

The next step, especially preferable for the plotting of maps in the scale 1:100,000, would be the use of the topographic stereoplotters such as Wild Aviographs, Kern PG2, Poivilliers Stereotopographe D and Santoni Stereosimplex II. Whether these are preferable to third-order instruments is more a problem of capital investment than of efficiency. It is not unlikely that these instruments, in particular, if the absolute orientation is known from camera orientation equipment, will show a productivity which compensates for the difference in investment compared to that of third-order plotters.

In case multiplex- or Kelsh-type instruments are used these will show such a large scale of the model that for a map 1:250,000 and even 1:100,000 a strong reduction must be applied. These instruments are less suitable for this kind of plotting than the 3rd order instruments and the cost per hour with one operator is not much less than of the topographic plotters.

Par. 4. Production of topographic maps in the scales between 1:10,000 and 1:50,000.

a). Photography.

The decisive factors effecting the scale of photography are the following:

1. The precision of the planimetry as derived from the errors in the ground control, aerial triangulation and the restitution of each single photograph.
2. The smallest possible contour line interval determined by the same elements.
3. The possibility of distinguishing the necessary topographic detail in the stereoscopic model with the use of available plotting instruments.

It depends on the type of terrain (density of details, contour line interval etc.) and the method of determination of control points which factor is decisive. For maps with contour line interval of 10 m and smaller it will be this value. Since especially in less developed areas aerial triangulation will always be applied to the production of these maps we know that the average standard deviation (s.d.) of arbitrary points of a model 1,2 times that of the control points. This gives for first class quality 1,2 x 0,03% H for height and 45 micron for planimetry. Assuming 150 micron for the s.d. in the position of a point in the manuscript this gives a possible ratio of scales between photograph and map of 1:3. For a map 1:25,000 this would allow a scale of photography 1:75,000 with a flying height H = 11.500 m (using a 15 cm wide angle camera). With these photographs the precision of height would be 0,036 % of H = 4 m. This makes it possible to plot with a contour line interval of 20 m or 50 ft, independent of the scale of the map. This example shows that for an interval of 10 m H must be 5500 m. In cases where the scale of the photographs need not to be large, the use of the super wide angle camera can be useful, which from 5500 m gives then photographs 1:62,500.

Another conclusion of this example is that the C-factor in both cases needs not to be better than 550 and that from this viewpoint precision plotters are not required. This is due to the errors in height introduced by the aerial triangulation. It may be, however, that the many small planimetric details to be plotted justify the use of precision or topographic plotters not because of their better C-factor, but because of the better images they present to the operator.

As a result of the various considerations of which that mentioned above is an example, we find a wide variety of scales.

Scale of the map	scale of photography.
1:10,000	1:10,000 to 1:40,000
1:25,000	1:20,000 to 1:40,000
1:50,000	1:30,000 to 1:70,000

There exists at present a fully justified tendency to apply the smallest possible scale of photography. This is especially important to less developed areas with a sparce network of ground control, aerial triangulation and orientation of the models in a plotter is proportional to the number of pairs. Reducing the scale in the proportion 1:n, the number of photographs is reduced $1:n^2$.

b). Control points.

Specially in less developed countries this will be a problem of aerial triangulation as discussed in Par. 2.

Here we stress again the importance of the use of APR and other auxiliary equipment with the photography.
Another important possibility to reduce the cost of aerial triangulation is a combination of a super wide angle and a wide angle camera in the same airplane. On the small scale super wide angle photographs, taken each second strip, the control points necessary for plotting the wide angle photographs are transferred stereoscopically. The aerial triangulation is then carried out with the super wide angle photographs only.

c). Plotting of the manuscript.

For flat terrain the rectifying procedure is recommended with direct tracing of rectified diapositives on a light table. For densely populated areas it is recommended to use, although no contours are needed, one of the stereoscopic 3rd order instruments. These are mathematically correct when using rectified photographs and they eliminate relief displacement in high buildings. Furthermore their stereoscopes give an excellent image.

For plotting of hilly and mountainous terrain we need for the scales 1:50,000 and 1:25,000 instruments of a moderate price with an excellent optical system, giving the highest possible resolving power with a precision which is adapted to a C-factor of the entire procedure of at least 1000 and can be handled by one operator-draftsman. We mentioned the so-called topographic plotters in Par. 3.d. which fulfill these conditions. We mention also the U.S. Balplex plotters and the Kelsh type which for this task are popular in the U.S.A. These instruments should be used with 3 projectors which reduce the time for absolute orientation and improve precision.

In some countries the expensive precision plotters and even universal precision plotters are used for the production of these topographic maps. Only a small contour line interval can justify the application of these high precision but also costly instruments.

It is obvious that for all topographic mapping in scales smaller than 1:5000 a thorough knowledge of geomorphology is of the utmost importance. The photogrammetric operator should not only be trained in photogrammetric restitution procedures but he should also be a real topographer with a fair knowledge of what must be represented in the map and why.

d). Field reconnaissance.

This kind of maps need a field survey for completion of the plotted manuscript. The best method is to have this done by the man who carried out the topographic photo interpretation, either the operator or a special topographer.

In several countries there exist rather detailed instructions for these field completion surveys, adapted to the required representation of the terrain on the final map. We recommend the study of the Topographic Instructions of the U.S. Geological Survey which give a good example.

Par. 5. Production of large-scale topographic and cadastral maps.

1. General remarks.

As explained before the basic difference between this kind of mapping and that mentioned in the previous paragraphs is that we have in general a much greater enlargement from photograph to map, in some cases up to 10 times and even more. The consequence of this is that more precise plotting instruments are used, although specially in this kind of mapping some variety of precision is possible. There are large-scale maps for which the space for project work on the map is more important than its linear precision. In that case the requirements for plotting will be much lower than for a precise map of a legal cadastral administration. The consequence is that in such cases different types of equipment can be used. Therefore we find that for many engineering projects maps are produced in Kelsh type instruments. The direct enlargement from photograph to map is in this case 1:5 and greater enlargement can only be obtained by means of a pantograph which, however, means loss of precision. It is the task of the staff of a cartographic organization to find out which method and equipment is, also economically best suited to the requirement of the wide variety of large-scale mapping projects. As it is not the aim of this paper to deal with the explanation of technical problems, we will limit ourselves to the remark that a great many of these cartographic problems for technical purposes in scales 1:5,000 to 1:2,000 and even 1:1,000 are basically the same as for topographic maps 1:25,000 and 1:10,000. The same kind of wide-angle cameras will be used and for plotting there is a choice between precision plotters, Kelsh type instruments. In some cases, even the new kind of topographic plotters can be recommended, although there the enlargement by means of a pantograph is reduced to only 5 times. Whether aerial triangulation can be applied depends also on the required precision and on the circumstances and cost of ground survey. With the use of the figures indicated in par. 2 each service can determine for itself which would be the best solution.

Because of the great importance of the subject we believe that it is more worth while to discuss in this paragraph one special question viz. that of the survey for land registration and cadastral administration, which is a great problem of almost all less developed countries. The author admits that here he repeats what he has published at other occasions, but he believes it justified because of the necessity to indicate solutions which can simplify this problem.

2. Application of air photography to Cadastral Surveys.

Photogrammetry can be used for the production of new cadastral maps in unmapped areas or to replace old maps. We must distinguish between different systems, such as legal and tax cadastre and furthermore, in a legal cadastre, between numerical and graphical systems. In this section we will deal with legal systems these making the highest requirements for precision and reliability. We exclude, however, terrain of class I, built up areas, as there photogrammetry cannot replace ground survey methods.

In almost all less developed countries a good graphical method will be entirely sufficient, on condition that the scale of the maps is in accordance with the size of the parcels.

Notwithstanding the good quality which can be obtained with precision plotting instruments, these plotters have only in a few cases been installed for cadastral surveys in countries where a new survey is desirable. The reason is perhaps that with three 6-hour shifts a day for maps in scale 1:2,000, the yearly production will be no more than about 175 - 250 sq.km per year. Such figures show that in many countries with unsatisfactory cadastral systems, the acceptance of high precision photogrammetric mapping procedures cannot solve their problems within a reasonable time and with a reasonable investment in photogrammetric equipment.

The author believes that in these countries a gradually developing photogrammetric cadastral survey would be the best solution. He strongly recommends to accept such a system, based on the fact, that a high quality airphotograph, on which all artificial boundaries are made visible by signalizing the boundary corners before photography, can be considered as a document. The requirements for a cadastral survey are first of all a reliable description of the boundaries as they were at the moment the parcel was established in agreement between the adjacent proprietors. The second condition is that it should be possible at any time to reconstruct these boundaries in the field with a precision, in accordance with the value of the land. These conditions can be fulfilled by the air photographs as such provided that the photographs are taken after delimitation of the boundaries and the signalization of all artificial boundaries have been carried out.

Measuring two perpendicular lines on each photograph between identifiable points enables the surveyor to rectify these photographs to a prescribed scale as for instance 1:2,000. Drawing white lines between the corners of the parcels makes of each enlarged photograph the basic material for a cadastral sheet on which the numbering of the parcels and other administrative operations can be carried out. Many cadastral surveyors have objections to this simple method, but the advantage is that it gives the less developed countries the only chance to produce within an acceptable delay a reasonable system of cadastral documents. A further advantage is that if at any time disputes arise, or further development takes place, it will be possible to put the diapositives of the original negatives in a precise plotting instrument and produce either a map or read coordinates in the machine and obtain the precision of a numerical procedure.

An objection may be that all these enlarged photographs are loose sheets independent of each other. Cadastral authorities in less developed areas should realize, however, that also the European countries have started with island maps without any geometrical relation between the various municipalities of a country. Therefore it may be that the second stage of development would be to create a geometrical network between the various photographs. This can be done either by ground survey or by means of aerial triangulation and a limited quantity of ground survey. This latter procedure is cheaper and as has been proved in a few countries, gives sufficient precision.

Another disadvantage of the proposed method is the requirements of organization. Among these the main point is that in the country an airplane must be continuously available, because the preparation of the terrain with delimitation and signalization of boundaries can only be carried out for areas of limited size which must be treated one after the other. A second difficulty is the signalization, which in some countries can only be carried out with very primitive material. This should preferably be done at the responsibility of the owners, otherwise the marks will be destroyed or they disappear before the photographs are taken. This, too, is a reason to treat not more than a few thousand acres at the same time.

Par. 6. Base maps for the survey of natural resources.

In the following list the scales of the maps which are most suitable for the representation of natural resources phenomena are indicated. These should be printed on topographic maps of the same scale this giving by far the best and the cheapest solution.

In many of the less developed areas these maps will not exist everywhere. In such cases coordination between the activity of a topographic service responsible for the production of these base maps and the services responsible for the natural resources survey will be highly desirable. It is a bad solution if the last service first produces a base map with very primitive means and a few years later the topographic service comes and makes the final topographic map. Under such circumstances it is for the natural resources surveyor nearly always sufficient to start with photomaps and even uncontrolled photo-mosaics, to which the findings of his natural resources survey can be transferred and reproduced photographically.

1) Geology etc.

1: 25,000 for specific projects (mining, detailed hydrology etc.)
1:100,000 for all geological, hydrological and geomorphological maps
1:250,000 for more remote areas of a country
1:500,000 and smaller for geological reconnaissance maps of large areas.

2) Agricultural purposes, soils, etc.

1: 20,000 for specific projects of intensive irrigation on relatively small surface areas
1: 50,000 for semi-detailed soils maps and soils maps of sample areas
1:250,000 for soils maps which give a review of soils condition of a whole country
1:500,000 and smaller: reconnaissance maps

3) Forestry and vegetation.

1: 10,000 - 1: 20,000 for forest exploitation
1: 50,000 - 1: 100,000 for forestry maps to represent a forest inventory survey
1:500,000 - 1:1,000,000 for overall vegetation maps of large areas

4) Various subjects for land tenure and rural cadastral administrations.

Maps of scales from 1:5,000 to 1:20,000 will be needed.
For surface transportation the same scale can be used.
For road construction in non-urban areas base maps of 1:50,000 will be sufficient.

Par. 7. Modern tools in less developed areas.

About this subject some remarks were promised in the introductory paragraph No. 1. They are essential as aerial survey at present is in that stage of development, where also electronics and modern tools become increasingly important. The time around 1960 can be considered as a kind of landmark in the history of photogrammetry.

Regarding air photography not only new super wide-angle lenses, but also instruments like airborne profile recorders for the determination of height and other electronic equipment for the determination of the position of the camera in the air are used. The electronic dodging printer is recommended by many organizations, in particular those selling such equipment. With respect to restitution instruments we see first of all the automatic recording of the machine coordinates in the stereocomparator as well as in classical analogue restitution machines. The high speed computer is a challenge to many survey organizations. The automation as a kind of final stage is an attractive subject on all photogrammetric congresses and at an exhibition you can always find a crowd of interested observers around such an instrument.

Not only electronics, but even more simple devices are introduced to facilitate the operation of instruments. The connections between the handwheels of an instrument and the pencil on the drawing table are in many cases made nowadays by means of servo-motors. The setting of the orientation elements in the past only by a simple motion of a screw, driven by means of a handwheel or knob, has also become the subject of a so-called simplification by means of servo-motors.

Seemingly, the development in the design of instruments goes in this direction, with the danger that a cartographic service, which wants to be up-to-date believes that without these tools it will be considered as old-fashioned. The author, being responsible for a very large

collection of photogrammetric instruments, which is as much as possible kept up-to-date gained some experience with electronics and those so-called simplifications. This gives him the right and at the same time imposes the duty on him to give a warning to all those, responsible for the purchase of aerial survey equipment , to be in this respect careful and rather conservative. In the less developed areas the proportion between wages and capital investment in modern tools is such that automation and several other instruments with the aim to speed up production, can not be recommended from the economic point of view. This may be different in countries with a shortage of labour, but this does not exist in less developed countries provided an adequate training programme for all ranks has been organized.

The second argument against a step towards electronic and automatic registration, computation, etc. is that in many cases it means the replacement of personnel which can be trained easily, by personnel, for whom the training is much more difficult and takes more time. In a cartographic service which wishes to use an electronic dodging printer and even no more than one instrument with automatic registration of coordinates, it will be necessary to have an electronic engineer at hand at any moment, because both these instruments will be entirely useless if the electronics fail. It is the experience of the author that this happens regularly. In particular the challenge to use dodging printers brought more than one service into difficulties. If there is no possibility for servicing such instruments on the spot, it is irresponsible to start with this kind of equipment and rely on mechanics, who live several thousands of miles away. To give an example, there exists one universal stereoplotter with an excellent mechanical coordinate printer, which never fails. The same instrument can also be delivered with an electronic automatic coordinate printer. In that case the mechanical coordinate printer disappears. To chose the modern solution would, in less developed areas, be a dangerous step which I would never recommend.

There exist a great number of fully reliable, classical instruments which can be used for aerial triangulation and plotting. A triangulation can be computed by desk machines, just as this has been done in many of the industrialized countries and in the author's office since the last 25 years. Why should a service take the risk of electronic tools which definitely will break down from time to time and try to skip a phase of development? The conclusion is that such modern tools can be introduced in cartographic services only if the entire level of development in science and techniques of a country not only depends on a few specialized people trained abroad, but has a broad foundation in the education of the people as a whole.

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FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A.5.1

Philippines

MINERAL RESOURCES DEVELOPMENT OF THE PHILIPPINES

By Benjamin M. GOZON,
Secretary of Agriculture
and Natural Resources

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

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MINERAL RESOURCES DEVELOPMENT OF THE PHILIPPINES

By Benjamin M. Gozon
Secretary of Agriculture and Natural Resources

Introduction

1. The Philippines is fortunate to be endowed with abundant and varied mineral resources. The country is considered to be one of the most highly-mineralized areas of its size in the Far East. This belief has been expressed before by not a few geologists and mining engineers who have had long experience in Philippine mining. The result of prospecting and exploration in many parts of the country confirms this with actual facts.

2. Despite this fact, however, the Philippines is still far from being industrialized and as such is still considered among the so-called underdeveloped countries. As it is now, the country is still primarily an exporter of raw ores and concentrates as we have not developed a local market for our minerals as yet. The result is that, with the exception of gold mining, only small increments of the intrinsic value of the metals or minerals exported to foreign markets accrue to the country.

3. While there is certainly much to be desired with regard to the status of the mining industry, the present activity in the industry, particularly in the proposals to put up a copper-zinc smelter and a steel mill or two, is an encouraging sign of what lies ahead.

4. However, in a free enterprise economy like ours, the Government can only influence the trend of mineral development. While it is true that the Government may lay out plans of expansion to cope with future needs of the nation, the implementation of these plans and the attainment or non-attainment of desired goals devolves as a rule on the private sector. It is therefore of vital importance that policies and activities of the Government should act as incentives to private sector so that they will be willing and in a position to carry out the plans towards the expected results.

5. Any Government worthy of the name should be aware of the fact that natural resources constitute one of the principal assets of the country. Thru wise husbandry of its natural resources, a country can attain economic stability and reap the fruits generated thereby. In the Philippines among other such resources we have abundant minerals that still lie untapped, unproductive in the bosom of our mountains.

Organization of National Mining Services

6. In order that our mineral assets can be ascertained, developed and made useful to the people, the Mining Act of 1937 and C.A. No. 136 creating the Bureau of Mines were passed during the early stages of the Commonwealth Government.

7. Under the law, the Bureau of Mines has the authority to administer and dispose of the country's mineral wealth for the interest and welfare of the nation. Our Constitution recognizes the so-called Regalian Doctrine which rules that all minerals, whether found in public or private lands, belong to the State, and may be disposed of only by concession, permit or lease to citizens of the Philippines or to parties authorized under the Constitution.

8. Under this provision, the Government determines what valuable minerals are present under our soil and lets the people know what rights they can acquire before mining them and using for our commerce and industries. The principal function of the Bureau of Mines, therefore, is to carry out the provisions of all laws pertaining to the administration and disposition of mines, minerals, mineral lands, and to enforce the rules and regulations concerning them.

Geological and Mineral Surveys

9. A general plan then for economic mineral development would call for the Government to facilitate the expansion of the mining industry and in the right direction. After experiencing the mining boom of 1936 and the subsequent let-down, this was made evident. Because at the time gold mining had already made a very creditable start in the Baguio district, it was believed that the best way to assure that this industry prosper and develop was to conduct a nation-wide, systematic and detailed geological survey of all possible gold areas starting with those already known to be gold-bearing. Why start with known ones? The reason is simple. Because at that time even in producing properties little was known of the true geologic setting of the ore deposits in individual mines, much less of the genetic relationship of these deposits in the region. Without this knowledge, mining would be a hit or miss affair and the chances of rapid expansion would be meager. Detailed geological survey on a regional scale would also assure the availability of new deposits to replace already exhausted ones.

10. While this policy of the Government cannot by any stretch of the imagination be considered as the reason for the tremendous development of the gold mining industry between 1938 and 1941, it cannot be denied that it exerted no small influence. Aside from the equitable provisions of the mining laws, reasonable tax burdens and the generally favorable business and financial conditions of the times, the fact that the Government had at last awakened to the need of a modern systematic geologic and mineral survey and had started to do something about it, must have convinced mining investors that the industry was a good risk. Forthwith, the gold industry grew by leaps and bounds. It may not be amiss to state here that the growth of the pre-war gold mining industry in the Philippines was perhaps unparalleled in the annals of world mining.

11. The plan of regional and detailed geological surveying applied to gold was also applied to other industrial minerals that were being discovered in more and more places throughout the country. The materials of war were needed in the world market. Manganese and chromite were added to our mineral exports of gold and copper concentrates and iron ore.

12. Sometime in 1939, the National Development Corporation, a semi-government corporation, in cooperation with the Bureau of Mines, embarked in mineral exploration activities on a large scale covering the vast lateritic iron resources of Surigao and the country's resources of coal and petroleum. These activities were in the nature of opening up the economic potentialities of our mineral resources where private enterprise was not as yet in a position to enter or was somewhat reluctant.

13. Equally as important in our canvassing of mineral deposits was the decision of our Government authorities to make a bid for some measure of industrialization in our heretofore purely agricultural economy. An agro-industrialization program was initiated which meant greater emphasis was to be accorded basic industries like iron and steel, building materials, power, fuel and fertilizer. This program ushered mineral economic development into a new phase of nation-wide activities.

14. Extensive mineral and geological surveys and drilling exploration were planned on short and long-term basis to supply the necessary raw materials that proposed industrial plants will feed upon. Implementation of these surveys was placed primarily on the shoulders of the Bureau of Mines. This office worked in cooperation with U.S. foreign aid agencies, such as Point 4, Mutual Security Agency, Economic Cooperation Administration, International Cooperative Administration and with the local government's Philippine Council for U.S. Aid (PHILCUSA).

15. Among the first surveys to be conducted under this set-up was that for manganese, a very important strategic mineral and a necessary constituent of steel. Our richer deposit of manganese were gone and replacement even of lower-grade and smaller occurrences were much needed. The survey coverage include the islands of Siquijor and Busuanga and later the Anda Peninsula of Bohol. Knowledge of ore mineralization resulting from this work helped miners in these areas in their operation.

16. The survey for construction materials and sand gravel deposits was carried out mainly in Luzon, and for fertilizer minerals, guano and phosphate rock, in the Visayas and Mindanao early in 1947. In 1953 the Coal Survey and Development of the Strategic Minerals Survey were put in operation.

17. The object of the coal project was to investigate the geology, ore reserves and the characteristics of the coal in 14 of the most important coal areas of the country. The coal project was completed in 1957. The information obtained would be invaluable in the greater exploitation of this fuel resource which is much under-developed as yet.

18. The survey for strategic minerals is on a much bigger and wider scale. It covers ferrous and non-ferrous minerals, such as iron, nickel, copper, chrome, manganese, lead and zinc and radioactive substances. It is really an attempt at a continuing inventory of the metallic mineral resources of the country for the nation's industrialization effort. The survey started in mid-1952, has covered forty-five provinces up to now and still in progress. Every year about half a million hectares is surveyed in reconnaissances, and 10% of which in detail.

19. Completed surveys so far are those of copper deposits all over the islands, the chromite deposits of Zambales, the manganese deposits of Palawan, Bohol and Siquijor, and nickel-iron-lateritic deposits of Nonoc and vicinity in the Surigao Mineral Reservation. An airborne-magnetometer survey of six principal iron areas in Luzon and Mindanao was performed under contract by Hunting Geophysics of London. At the same time a radiometric survey was also made.

Exploration Work

20. Other Government activities in the line of mining promotion are the drilling exploration projects conducted by the Bureau of Mines in connection with the geological and mineral surveys mentioned above. Diamond and/or hand auger drilling made on chromite, manganese, laterite, coal, asbestos, clay and

other deposits disclosed not only valuable geologic information but also their vast economic potentialities as well.

21. We can mention the diamond drilling program conducted by the Bureau of Mines, in cooperation with National Economic Council (NEC) and Agency for International Development (AID), in the Government chromite reservation in Zambales. This exploration work has led to the present leasing of the reservation to a private mining company. Likewise, exploration diamond drilling and hand auger drilling presently being conducted by the Bureau of Mines in the nickel-cobalt-iron-bearing laterites and serpentinites of the Surigao Mineral Reservation has tremendously increased the previous reserve estimates. If the Government's plans to utilize this enormous resources are pushed through, it will mean a big forward boost to our developing economy.

22. Also, in connection with the strategic minerals survey previously mentioned, is the geophysical survey by ground magnetometric method started last year in two operating iron mines in Zamboanga del Sur and Camarines Norte to verify the magnetic anomalies established from the initial airborne-magnetometer survey of these areas. The survey has so far covered a total of 1,400 hectares of detailed work. It is planned to conduct similar studies in other principal iron areas.

23. This drilling work by the Bureau of Mines is also made available to the private parties at minimal fees or the drilling equipment may be leased under certain terms. Small mines or those with limited capital are especially benefited by these services.

24. This does not mean, however, that an inventory of the country's mineral resources is made possible through government efforts alone. Far from it, here as anywhere in the free world, it is private enterprise that performs most of the task. The successful operation of mining companies requires that all reserves be determined as much as possible ahead of mining or exploitation.

25. From a very modest start in exploration drilling, indications of our fuel potential from oil and gas reserves are quite encouraging. Deposits of gas of substantial size have been encountered in Cebu and Cagayan. More recently, the first flowing of oil well was discovered in Maya, Daanbantayan, Cebu. The field is still under study. However, the opinion of oilmen is that prospects in the Philippines are good with only about 5% of the potential areas tested.

Research Studies

26. Metallurgical research studies are conducted on a continuing basis by the Bureau of Mines in cooperation with private industry and with other government agencies. These include investigations on suitable techniques necessary to produce marketable concentrates from low and off-grade ores of iron, copper, chromium, titanium and other base metals.

27. Extended beneficiation studies of feldspathic rocks, gypsum, diatomaceous earth, clays, asbestos, phosphate rock, sulphur and other non-metallic minerals are also conducted to determine their amenability to particular processes. Likewise, tests are made in the continued effort to utilize local coals and other carbonaceous materials for metallurgical and other uses.

28. All these activities have contributed in no small measure to the exploitation of these otherwise non-commercial materials.

Training of Technical Men

29. In order to have the necessary complement of trained men and to help advance local mining, geological and metallurgical know-how, the Bureau of Mines, in cooperation with the NEC-ICA (now AID), Colombo Plan Organization, the Federal Republic of Germany and the International Atomic Energy Agency, is carrying on a traineeship program for its technical personnel.

30. As of June 30, 1962, the Bureau of Mines has sent 64 of its personnel for specialized training abroad under its training grant program: 41 in geology, 9 in mining technology, 11 in metallurgy, and 3 in mineral lands administration.

31. With the assistance of the United Nations, a school of applied geology, a project of the Bureau of Mines in cooperation with the University of the Philippines, is expected to be set up soon. This is another move to further upgrade the training of our technical men in order to develop and expand the mining and mineral industries.

Government Legislation

32. Legislation is also another means that the Government makes use of to foster the development of our mineral resources. From the very beginning of the post-war period, the Bureau of Mines, through the Department of Agriculture and Natural Resources, recommended a number of measures which it believed could push mining rehabilitation at a much faster rate.

33. One of these was the passage of R.A. No. 81 which exempted holders of mining claims from performance of assessment work from 1941 to 1947 inclusive, later amended by R.A. No. 215 with an extended time limit till 1949. Under certain terms and conditions, exemptions from payment of mining, specific and real estate taxes were allowed for the period. This legislation was a very welcome relief to the mining industry. It avoided or at least minimized the confusion and the conflicts that otherwise would have resulted in the relocation of claims where records had been lost or destroyed. A similar legislation was R.A. No. 743 providing protection to locators, lessees and operators of unpatented mining claims and leases by exempting them for the years 1951 to 1953 inclusive from annual assessment work required by existing laws.

34. Other pieces of legislation very helpful to mineral development and the promotion of mining operations were those enacted for the reduction of production tax on all mines to a flat rate of 1-1/2 per cent; exemption from payment of income tax during the first 3 years of actual commercial production for certified new mines and old mines resuming operations under certain provisions; and exemption from the special excise tax of 17% on foreign exchange for imported mining machinery, equipment and supplies for the exclusive use of mining operators themselves.

35. The passage of the Petroleum Act of 1949, together with the publication of the Corby report on the Geology and Oil Possibilities of the Philippines was considered the spark plug that started oil interest in this country. Incidentally, foreign experts are of the opinion that our Petroleum Act is one of the best petroleum laws in the world.

36. The Gold Subsidy Law (R.A. No. 1164) of 1954 kept the majority of gold mines in operation during the past crucial inflationary years. The recent Gold Assistance Act (R.A. No. 3089), later amended by R.A. No. 3472, passed by Congress was another timely attempt to save the gold industry which has contributed so much to the economy of the nation. It was an admission that the industry deserves a better fate. In the meantime, it is hoped that

long-range program can be arranged so that the industry can be revitalized and that the country can continue to produce this monetary commodity, convertible any time and anywhere in the world.

37. What the gold subsidy was to the gold industry, the barter law was to many base metal mines. It had saved many operations from closing down. The base metals had also their ups and downs. Because they have to compete in the world market, when the market is a seller's market there is more activity in base metal production. On the other hand, in a buyer's market, activity subsides and producers go a-begging.

38. Other Government activities in the line of mining promotion are long-term loans for rehabilitation, development and expansion purposes, and recently, the monetary decontrol program which enables our mineral producers to get higher peso exchange rates from the dollar proceeds of their mineral exports.

Conclusion

39. Our mineral resources picture is certainly something to be optimistic about. While before the war we were known principally as a producer of gold, now we produce twelve metal commodities in substantial amounts. The Philippines is still among the top ten gold producers of the world. Our refractory chromite export to the U.S. supplies that country with 80% of its requirements. Our copper production is 13th among those of the free world. We are one of the few quicksilver sources in the mineral market and we may yet make a dent in the molybdenum mart.

40. All the aids and/or incentives previously mentioned from the Government, whether legal or technical, have one object in common, that is, the promotion of the mineral resources development. In a few of these we may not have achieved as much as was expected (as in the rehabilitation of more pre-war mines, in the matter of loans, and in the nickel-iron smelting project) but on the whole the effect of the majority of them is a new awakening and revitalization of the country's mineral industry, metals, non-metal and petroleum.

41. In no time in the nation's history were investors as minerals conscious as in the post-war period. Our mining industry could have attained its pre-war status and perhaps surpassed it, were it not for the financing difficulties. But financing difficulties and precarious economic balancing are not the exclusive lot of our Government and private sector. It is also the lot of many nations throughout the world, even big and small, and especially the newly-freed ones and the so-called underdeveloped, because the very nature of world economics and national growth seem to require that they pass through this stage of growing pains. It is a consoling thought that in the opinion of world economists our country as a whole has not been too badly off.

42. The post-war period has given birth to four out of five large copper producers today, seven iron mines, two chrome mines, one quicksilver mine, one rich lead and silver mine of short duration, a producer of molybdenum and a host of producers of non-metals which have not been exploited before. In this post-war period, we have put up six large cement plants, another big glass factory and a ferro-alloys plant. Soon we may have an oil producer, no matter how small, and there are already two refineries in operation with two more to go on stream in a few months. Perhaps even the establishment of our nickel industry is not so far distant.

43. In a free enterprise economy like ours and under conditions of abundant resources, mineral development and utilization can be brought to their highest level and in the minimum of time provided close cooperation and mutual understanding of objectives and problems exist between the Government and private sector. As shown by recent events, the present Administration is already providing bigger and better incentives as circumstances will allow and the private sector on the other hand is responding with greater expansion of operation and diversification into new mineral enterprises with characteristic courage and resolve. From here on we can look forward to a more rapid acceleration in our mineral resources development in the Philippines.

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Point de l'ordre du jour : A.3.4.1

Portugal

OBSERVATION DE LA PRECIPITATION PROVENANT DU BROUILLARD DANS L'ARCHIPEL DU CAP-VERT

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Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.

3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

4. Préalablement à la Conférence, les mémoires et les résumés ne feront pas l'objet d'une distribution générale mais d'un tirage restreint destiné aux délégations des gouvernements et autres participants officiels. La publication et la distribution générale des actes de la Conférence s'effectueront conformément aux règles et pratiques agréées par le Comité des publications des Nations Unies.

Observation de la précipitation provenant du brouillard dans l'Archipel du Cap-Vert

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Dans les régions du Globe où le brouillard est fréquent et le vent souffle avec une fréquence et une vitesse telles qu'il y a continuellement une forte advection d'air humide, l'eau provenant de cet hydrométéore pourra représenter un rôle important dans le cycle hydrologique, comme on l'observe dans quelques zones d'altitude des régions tropicales arides, où l'eau provenant de cette origine dépasse appréciablement la valeur de la quantité de précipitation. D'un autre côté, le brouillard a une action indirecte sur le cycle hydrologique du fait de réduire grandement l'évapotranspiration; et, de plus, il semble que les plantes sont susceptibles d'absorber de l'eau directement par les feuilles, laquelle circulant en sens contraire à celui de la sève pourra, en partie, être emmagasinée dans le sol, comme on l'a observé dans les régions arides où, de ce fait, s'explique l'action utile de la rosée et la raison pour laquelle beaucoup de plantes arrivent à végéter dans un milieu sans eau.

A l'archipel du Cap-Vert, les pentes tournées vers le Nord et le Nord-Est, entre approximativement les niveaux de 500 et 1000 m présentent les caractéristiques mentionnées, car, pendant une grande partie de l'année et spécialement pendant la longue époque sèche (Novembre à Juin) ces régions sont enveloppées par le brouillard par suite de la couche de stratocumulus et cumulus qui se forme par turbulence et convection orographique du courant des alisés.

La captation de l'eau du brouillard dépend essentiellement de l'existence d'obstacles naturels ou artificiels susceptibles d'arrêter et recevoir les gouttelettes qui y choquent en plus grand nombre possible. En conditions naturelles, sans aucun obstacle pouvant exercer une action en ce sens, le brouillard ne contribue pas, en général, pour plus de 0,2 mm de précipitation par jour, mais s'il y a un obstacle vertical, par exemple un filet métallique et si la vitesse du vent est de l'ordre de 35 km/h l'expérience a montré que l'eau recueillie pourra correspondre à une précipitation d'environ 18 mm à l'heure, la quantitée captée étant fonction de la vitesse du vent et cette variation est de l'ordre de 5 mm/h pour chaque variation moyenne du vent de 10 km/h, au cas où l'on considèrerait comme valeur raisonnable que la quantité d'eau contenue dans le brouillard est de l'ordre de 0,4 g/m3.

Nous pouvons estimer pour les dites régions du Cap-Vert la quantité d'eau qu'il est théoriquement possible de capter par un filet métallique de la superficie de 1 m^2. Considérant que les dimensions des gouttelettes du brouillard sont de l'ordre de 20 à 30μ, que l'efficacité du filet est de 40% en relation au passage total des gouttelettes, valeur obtenue par expérience, et que la vitesse moyenne du vent pour ces mêmes régions est approximativement de 30 km/h, on observe que l'on pourra par ce moyen recueillir près de 50 litres d'eau par jour correspondant à la période nocturne (12 heures), quantité qui, en quelques jours, pourra être supérieure par suite de ce que, en général, le brouillard ne se dissipe pas totalement pendant la période diurne.

L'idéal serait d'utiliser des filets métalliques réfrigérés artificiellement, car on sait que dans un nuage le poids de vapeur d'eau contenu dans l'air est généralement plus de dix fois supérieur à celui de l'eau dans la "phase condensée", mais ce procédé est, en général impraticable, particulièrement aux îles du Cap-Vert. Cependant, d'autres procédés, outre celui du filet métallique, pourront être expérimentés, tels que l'utilisation de la flore naturelle et celui de tas de pierres. Ce dernier procédé a été employé autrefois en Crimée et son utilisation dans l'archipel se revêt d'aspects particulièrement à considérer en face de sa grande économie. En d'autres régions du Globe des études analogues sont en train d'être faites, comme en Australie et à Gibraltar pour l'utilisation de filets métalliques.

Pour la première fois en Portugal des observations de captation de l'eau de brouillard, en des conditions naturelles, ont été faites par le Prof. M. de Azevedo Gomes, dans la "Serra de Sintra", qui a observé que la quantité d'eau recueillie par les pluviomètres installés sous le feuillage des arbres est appréciablement plus grandeque celle mesurée dans les pluviomètres installés en conditions normales, les différences étant plus grandes en été, époque à laquelle, sur le littoral occidental du continent portugais le brouillard est plus fréquent. Dans l'île de Santo Antão, au Cap-Vert, des observations analogues ont été faites par l'Ingénieur Gonçalves, la différence des quantités d'eau recueillies dans les deux conditions mentionnées étant extraordinairement grande, quoique dépendant de la situation des pluviomètres sous le feuillage des arbres, ce qui montre bien les possibilités qui existent d'une captation d'eau du brouillard dans les régions considérées.

Dans la partie la plus haute de l'île Brava il existe déjà une captation d'eau de cette origine qui est utilisée à des usages domestiques. En effet, Monsieur Hermogenes Gonçalves, petit cultivateur à "Campo das Fontes" (désignation incompréhensible dans une région où il n'y a ni fontaines ni puits et où l'eau pour les plus simples besoins doit être apportée de grande distance) a eu l'heureuse idée d'utiliser le fourcroya (Furcroya gigantea) pour recueillir l'eau qui coule sur les feuilles de cette plante, provenant du brouillard. D'après ce que M. Hermogènes Gonçalves nous a conté, cette idée lui a été suggérée en 1942, en pleine grande crise, quand les difficultés pour obtenir de l'eau étaient énormes, en observant que des feuilles de fourcroya dégouttait de l'eau qui tombait sur le sol. Il a alors réuni les feuilles d'une même plante, de manière à ce que toute l'eau coulât vers un seul point, il a placé un petit récipient au-dessous et quelques minutes après il était complètement plein, ce qui lui a causé une joie bien naturelle. Il a utilisé de la même manière d'autres pieds de fourcroya et l'eau obtenue a été en telle quantité qu'il a cessé d'avoir besoin de l'aller chercher à un puits situé au Cachaço, à une grande distance du local. Actuellement, il utilise dans ce but environ 60 de ces plantes disposées en file, en terrain incliné. L'eau du brouillard captée par les feuilles tombe dans une gouttière, fait avec les feuilles de la même plante et qui termine dans un petit réservoir qu'il a construit exprès pour recueillir cette eau. Par ce procédé, il arrive à recueillir, en moyenne, presque 10 bidons de 20 litres (1)

(1) Mesure usuelle aux îles du Cap-Vert.

d'eau par nuit, mais quand le brouillard est dense et le vent fort, il capte des quantités plus grandes qui sont déjà arrivées à 30 bidons, soit environ 600 litres. À ce qu'il nous a dit, un seul pied de fourcroya arrive à capter un bidon de 20 litres par jour quand les conditions sont favorables.

Comme première phase de l'étude de ce problème, on a installé au Cap-Vert quatre pluviomètres avec l'attrape-brouillard de Grunow (Fuess) qui comportent un filet métallique cylindrique qui se place au-dessus de la bouche des pluviomètres de façon que l'eau du brouillard captée par ce dispositif puisse tomber dans ces instruments et être, par conséquent, mesurée. On a installé des pluviomètres avec cet acessoire à côté d'autres en conditions normales et sous le feuillage des arbres à Curralinho (Santiago), Monte Velha (Fogo) et à Pero Dias et Água das Caldeiras (Santo Antão).

Les résultats déjà obtenus permettent de constater que la quantité d'eau recueillie par les pluviomètres avec le dispositif de Grunow est appréciablement plus grande comme on peut le voir, par exemple, par les totaux des valeurs obtenues pendant la période de Novembre 1961 à Juin 1962 à la station météorologique de Pero Dias, dans l'île de Santo Antão, à 1110 m d'altitude:

Précipitation totale en conditions normales 141;8mm
Précipitation totale sous le feuillage des arbres 158;4mm
Précipitation totale avec le dispositif de Grunow 688,4mm

Ces premiers résultats permettent de prévoir de réelles possibilités pour que l'on continue cette étude. Il est évident qu'il est impossible de capter de l'eau de brouillard en grandes quantités, mais il est sans doute viable de l'obtenir pour la consommation des familles et pour les animaux; et si l'on y arrive par des moyens économiques, le problème de l'eau pour cette finalité pourra être résolu, en grande partie, dans les régions signalées du Cap-Vert.

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Philippines

GEOLOGICAL MAPPING METHODS BY THE PHILIPPINE BUREAU OF MINES

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

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GEOLOGICAL MAPPING METHODS BY THE PHILIPPINE BUREAU OF MINES

Elpidio C. Vera, Assistant Director

(1) The Republic of the Philippines, through the Bureau of Mines, continues its efforts to obtain geological information and determine the mineral potential of the country. The present policy is to increase the tempo of mapping activity with emphasis on: (a) Regional reconnaissance mapping to establish the guiding system that will provide a basis for segregating priority areas as well as extrapolation of potential zones; (b) Semi-detailed mapping to decide on whether or not to go through the more costly and time-consuming detailed survey; to publicize mineral areas attractive for investment; and in the field of engineering, to provide substantial guarantee on the feasibility and safety of erecting structures on the area; (c) Detailed mapping to help implement selected engineering projects or economic projects of the government and assist private parties or companies in the development of mineral prospects. Spot investigation mapping is also being maintained as a technical public service.

Regional Reconnaissance Mapping

(2) Regional reconnaissance mapping in the Philippines was started in 1939 under the management of the National Development Company.[1] It was conducted specifically to investigate oil possibilities and was limited to areas occupied by thick Middle Tertiary to Quaternary sediments. Field work was done on a contract basis by a group of American geologists over a period of one and a half years. The procedure consisted of making a careful study of several selected sections to establish stratigraphic faunal control and for subsequent reference. The scale of mapping varied from 1:20,000 to 1:50,000 and a base map in the scale of 1:200,000 was used in the presentation of the report.

(3) The Bureau of Mines made efforts to start reconnaissance geological mapping in 1947 but primarily on areas reported to have mineral potentiality with the aim of accelerating the growth of local industry. It was handicapped by the lack of precise base maps, few experienced men and difficulty of mobility. In addition, there was a necessity of building stratigraphic control concurrently with the progress of mapping. Survey work was generally carried on foot. The scale of base maps used was generally 1:25,000. An annual coverage of about 2,500 square kilometers was made which increased steadily to about 4,000 sq. kms. in 1954. With the availability of precise base maps from Washington, D.C., U.S.A. in the scale 1:50,000 time loss in the base map preparation was eliminated, and with the acquisition of jeeps for the survey and increase in fieldmen, the rate of mapping was gradually accelerated to as much as 5,420 sq. kms. in 1959. The scales of 1:25,000 and 1:50,000 of base maps were used.

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1 A government corporation created in 1911 to further the economic policy of the Philippine Commonwealth.

Need for Revising the Method

(4) The rate of mapping up to 1959 still proved very unsatisfactory as the total coverage till then was only 10% of the 297,500 square kilometers total land area of the Philippines. To survey the remaining areas at that rate excluding those reliably mapped by petroleum companies would require around 40 to 50 years more. In addition, as formational segregation was used in the old procedure and various names were introduced on lithology from island to island, considerable confusion arose in correlation. This is especially true in the lithologic sequence of the lower Tertiary and older, where paleontological evidences are scanty. The need for a change, therefore, was very much felt if it had to establish a regional geologic map in the shortest time possible so as to provide a guiding system, segregate priority areas that can bring about immediate economic returns and provide sound basis to extrapolate potential zones.

(5) Basically, therefore, the revision of our mapping is guided by the followings

(a) To substantially reduce foot work and at the same time maintain precision, and

(b) Benefiting from already established stratigraphic controls, to segregate the lithology by time-rock units to minimize difficulty in correlation.

Present Method

(6) The present method of regional reconnaissance mapping designed to produce a complete geologic map of the Philippines by 1965 consists essentially of the following steps, in addition to the standard operational procedure.[2]

(a) Preliminary photogeologic interpretation and planning of field traverses;

(b) Foot traverses are done only on selected lines and readily accessible areas and field parties are mechanized to expedite movement;

(c) With proper field controls, photogeologic interpretations are checked and readjusted. In general, delimitation of structures and lithologic boundaried are done by photogeology.

(7) The geologic map worksheets are in the scale of 1:50,000 and compilation is done on 1:250,000 scale.

Pending Problems

(8) With ten parties assigned in regional mapping the program is beset with problems in the completion and finalization of the work into publication. In order to remedy the situation it is desired (a) to increase laboratory facilities and

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2 Standard mapping procedure in this country consists of making field traverses, commonly along creek beds. Rock formations are studied and sampled. Geologic structures are measured by use of brunton compass and are located with the use of base maps in the scale of 1:50,000. Geologic notes are recorded on field books. Samples collected are indexed and further studied in the camp and later sent to the central office laboratories for additional study either petrographically, paleontologically or chemically.

technicians, and to introduce the method of absolute age determination; (b) to establish regional laboratories to facilitate study of the collected samples; (c) to furnish each field party with a petrographic microscope; (d) to provide good working space for geologists; (e) to increase efficiency in writing reports; (f) extend generous library facilities; (g) in the case of fieldwork, there is need for simplification in the procurement of equipment and supplies, and disbursement of field expenses; (h) secure technicians to specialize in modern map preparation and reproduction processes.

Semi-detailed Mapping (Present state)

(9) Semi-detailed mapping is carried out only on specific areas such as (a) those segregated by regional reconnaissance to be prospective for mineral deposits; (b) abandoned mineral prospects and mine areas to determine the feasibility of resuming exploration and exploitation; (c) sites selected for major engineering projects; and (d) areas of scientific interest.

(10) The work as carried out is presently divided under four groups: (a) survey of metallic deposits, (b) survey of non-metallic deposits, (c) engineering geology and geohydrological survey, (d) geophysical and geochemical surveys.

(11) The first two groups follow practically the standard procedure of reconnaissance work except that traverses are spaced more closely to insure precision in the projections of geologic structures. In addition, calculations of geological reserves are made. Base maps are prepared by enlarging the 1:50,000 photogrammetrically prepared topographic maps by U.S. Army Engineers supplied to the Philippine government to a scale of 1:10,000 greater or less, but in no case smaller than 1:25,000. Sketches of the outcrops of the deposits are done in a larger scale, enough to accommodate valuable geologic data. Traverses are usually controlled by the tape and compass method. Depending on the nature of the problem this survey oftentimes becomes nearly detailed in nature.

(12) The other two groups are still limitedly applied at present. Airborne magnetometer survey has been run in a few places which are deemed potential for iron deposits while ground magnetometer survey is being continually tested and the process of training technicians is still going on. Geochemical prospecting was tested in 1960 and is now being applied in a regional scale in stream sediments and waters in mineralized regions.

Problems of Semi-detailed Mapping

(13) The Philippines is passing through a phase of rapid evolution from a state of economic attachment and dependency on the United States to one of economic independence. The growing need for this survey had been felt in the past and is expected to grow much more rapidly especially after the preliminary regional reconnaissance is completed. The fields of geophysics and geohydrological engineering are equally expected to play an important role in the location of sources of ground water. The numerous newly established factories and increase of urban population would considerably aggravate shortage of industrial and domestic water supply. The growing scantiness of surface deposits may soon require considerable reliance on geophysics and geochemistry. These problems must be solved at the earliest time possible.

Detailed Mapping

(14) Detailed geological survey is a country-wide concern of many private companies. The Bureau of Mines limits this survey primarily to known mineral deposits and mineral reservations and only occasionally assists in the geological study of operating mines. Detailed mapping is also conducted to investigate foundation conditions, sometimes to determine the availability of construction materials

in selected sites of major engineering projects.

(15) The survey is usually divided into two stages; (a) Preliminary investigation stage, and (b) exploration stage.

(16) The preliminary investigation stage is essentially surface geological mapping in which plane table is used to make a precise topographic map and to locate accurately observable geologic features. The general geologic map commonly ranges in scale from 1:1,000 to 1:5,000. Critical areas and exploration openings are mapped in a larger scale to permit accommodation of many details. The subsurface explorations performed at this stage are of the simple types as test pitting, trenching and dogholes and their adoption depends on the characteristics of the area. Where outcrops are wanting, more elaborate test pitting and trenching are done. The exploratory openings are studied and logged. The final study includes making of geologic sections and planning for systematic exploration.

(17) The second stage of detailed mapping operation is performed only on very limited projects that require thorough exploration or evaluation. This is usually conducted by resident geologists assigned to the projects, who further map new openings and log drilled cores, new test pits, tunnels, etc., and subsequently recommend either changes in work, remedial measures or termination of exploration work depending on their findings. In the case of mineral deposits, evaluation and computation of ore reserves are done.

(18) Geophysical methods are still rarely used. In cases where applied (ground magnetometer and geochemical), grid lines and stations are plotted by plane table survey.

Problems of Detailed Mapping

(19) The preparation of large scale topographic maps for detailed mapping often consumes considerable time and man-hours. The present available 1:50,000 topographic map sheets are not accurate enough for the purpose. In this consideration, plans are being made to secure low altitude photographs and to prepare by multiplex methods accurate large scale topographic maps. This can be used to upgrade the accuracy of semi-detailed and spot investigation surveys.

(20) Another problem being considered is in the field of mineral resources development. Outcrops and near-surface deposits are rapidly getting so scarce that future surface geological mapping may not be enough guarantee for immediate capital investment. It is desired to start an early expansion of the present geophysical and geochemical staff to give ample time for their training, development and adjustment of methods adaptable to local conditions.

(21) In the field of geohydrological engineering, detailed mapping and geophysical methods are very likely to be employed soon, as is being done at present in more advanced countries. The training of men to conduct such surveys is very much desired to be started at present. In addition map reproduction processes have to be updated.

Spot Investigation

(22) Spot investigation survey is a form of technical service extended to the public, private companies and/or government entities needing rough geological information or evaluation on specific areas. This survey covers a very broad field of study, running from strictly economic geology in nature to engineering geology and water supply problems. Sometimes, to investigate protests of citizens against mining companies regarding river pollution; to locate good sources of underground

water for industrial uses; to determine causes of landslides or other forms of mass wasting and to suggest remedial measures. In such cases the problems are unpredictable, even the locality may be uncertain.

(23) As the nature of the problem requires immediate decisions, the Bureau assigns this type of survey only to capable geologists of long experience. The methods used vary, sometimes unconventional and unique, depending a great deal on the nature of the problem and the needed answer of the requesting party. However, ordinarily the geologist conducting spot investigations carries with him the standard geologist's tools plus tape and altimeter. Base maps in the scale of 1:50,000 are used and large scale maps are done only as sketches. Laboratory study may or may not be required.

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